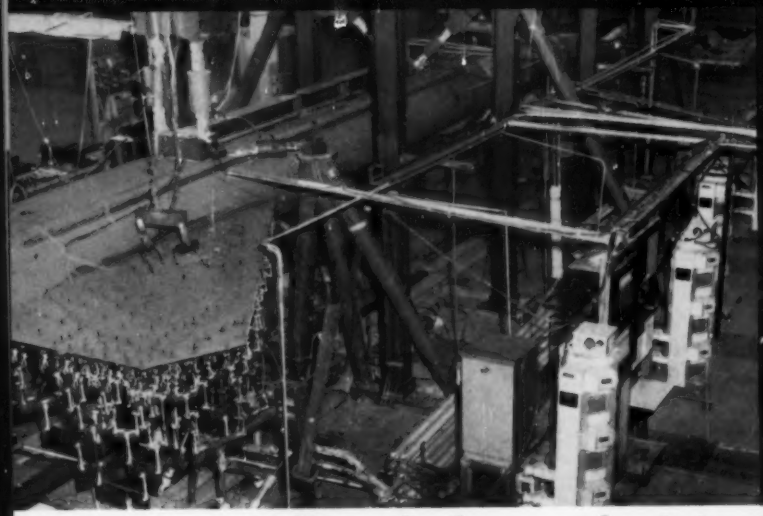
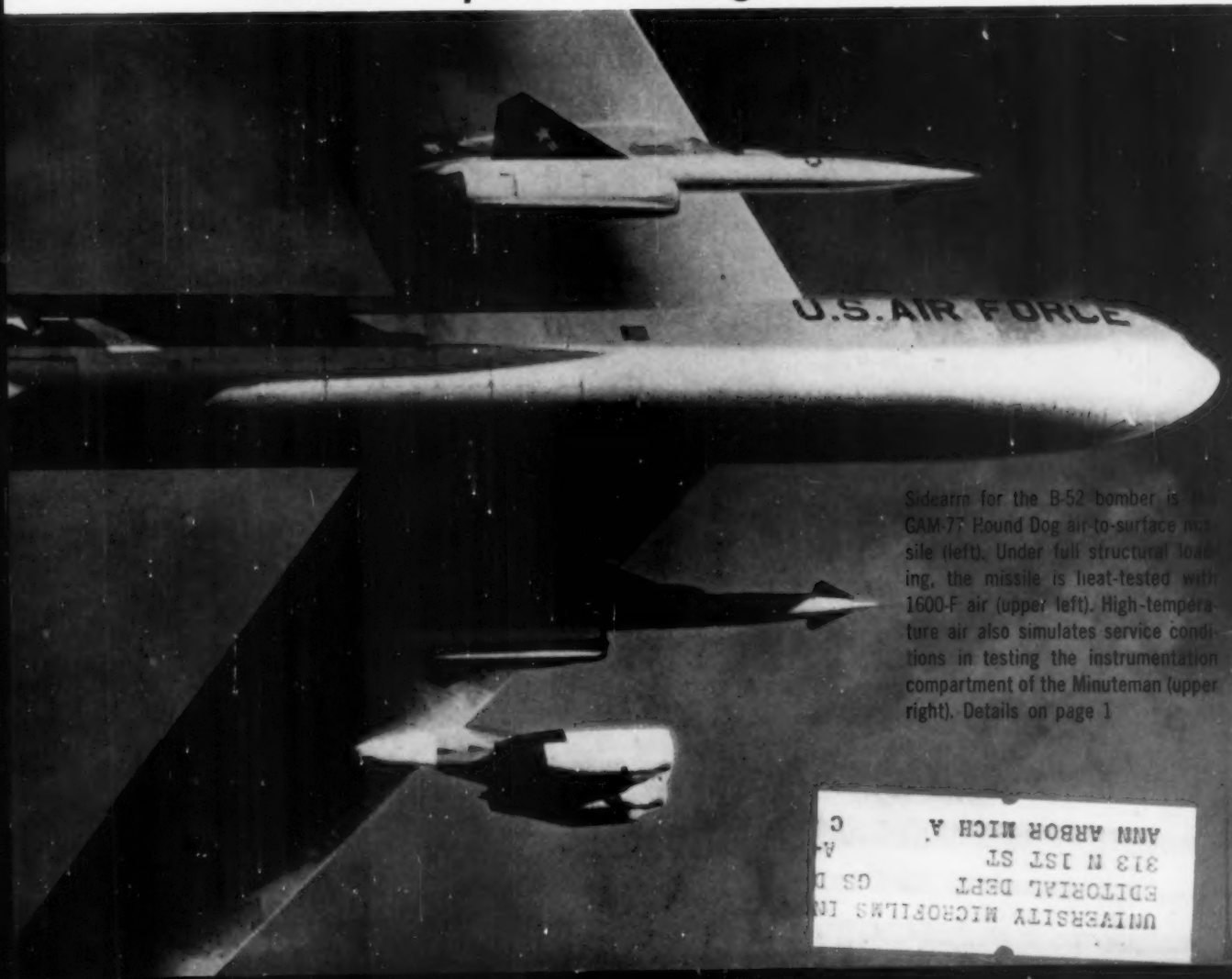
PRICE 50 CENTS

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · JULY 31, 1961

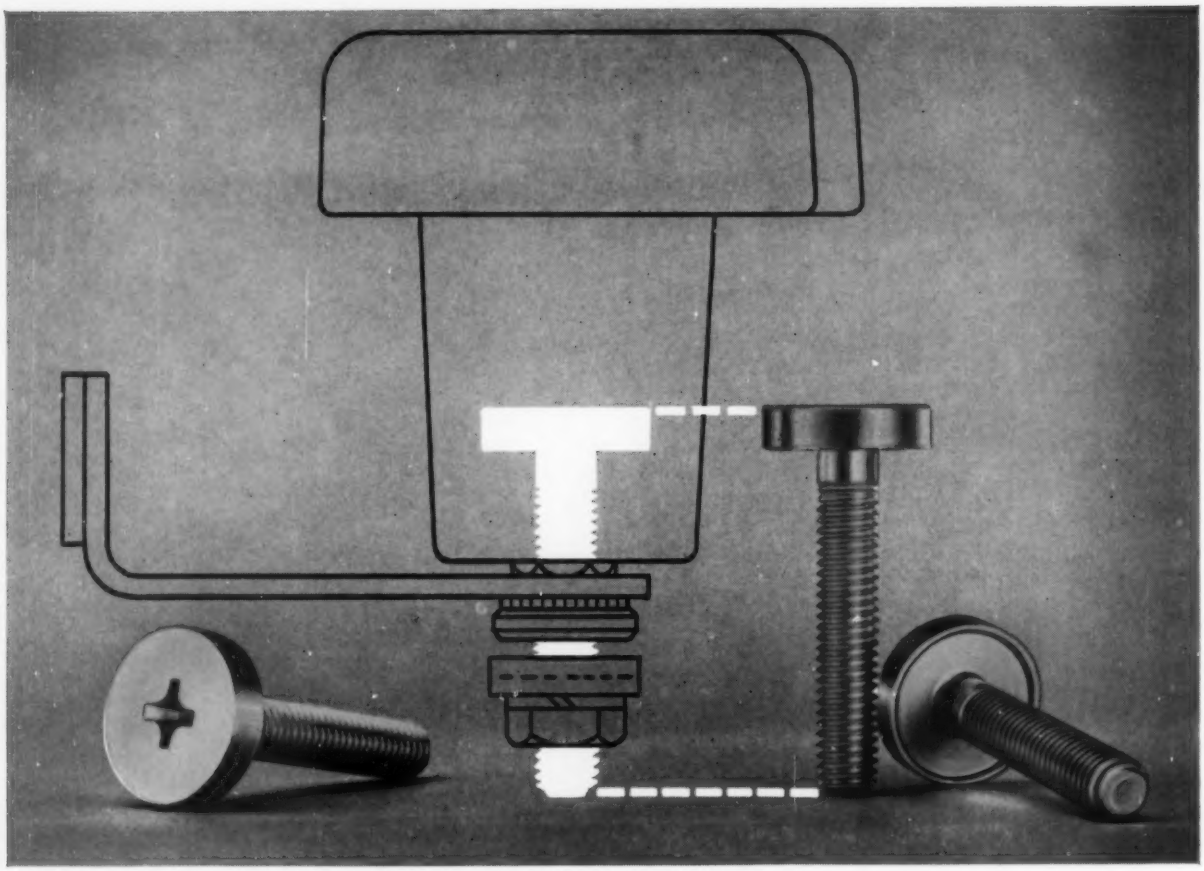


Hot air for product testing... SEE PAGE 26



Sidearm for the B-52 bomber is the GAM-77 Hound Dog air-to-surface missile (left). Under full structural loading, the missile is heat-tested with 1600-F air (upper left). High-temperature air also simulates service conditions in testing the instrumentation compartment of the Minuteman (upper right). Details on page 1

UNIVERSITY MICROFILMS INC
EDITORIAL DEPT GS D
313 N 1ST ST A-
ANN ARBOR MICH A C



CUNISIL, new Anaconda copper-nickel-silicon alloy, gives you high strength for tough electrical jobs

THE PROBLEM: The studs for Line Materials Secondary Class Lightning Arresters (illustration above and below left) call for an unusual combination of properties. They must have high physical strength for structural reasons and to handle the stresses of high surge currents. Yet they must also have relatively high electrical conductivity. And for economical fabrication, the alloy must have good cold-forming characteristics and be readily machinable.

LINE MATERIALS Type S-3 Secondary Class Arrester with stud of Cunisil, copper-nickel-silicon alloy. Cunisil is also used for lower studs of Line Materials Protective Gaps.

THE SOLUTION: Continental Screw Company, which makes the studs for Line Material Industries, found the answer in Cunisil-837, Anaconda's versatile new high-strength, heat-treatable alloy with these valuable properties in the precipitation-hardened condition:

Tensile strength—psi min.	90,000
Yield strength—at .50% extension under load, psi min.	70,000
Elongation in 4 x D, min.	8%
Machinability, (Free Cutting Brass=100)	40
Electrical Conductivity, % IACS, as heat treated	30 to 42

In addition, Cunisil-837 has corrosion resistance comparable to copper and Everdur® copper-silicon alloys—and is easy to work cold before heat treatment.

METALLURGICAL COMMENT. Most of the nickel and silicon in heat-treated Cunisil is present as an intermetallic compound, nickel silicide, and it is the precipitation of nickel silicide in the form of particles of submicroscopic size by a relatively low temperature heat treatment that accounts largely for the distinctive properties of the alloy.

Prior to the hardening heat treatment, the alloy is brought to a proper condition for hardening with a solution anneal at a much higher temperature and then a water quench from this temperature; at this stage the alloy is quite soft and in a condition for drastic cold-working operations. The hardening heat treatment consists of heating at a controlled temperature for a definite length of time to obtain the desired mechanical properties.

For more information—see your Anaconda American Brass representative, or write: Anaconda American Brass Co., Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6149

ANACONDA®

COPPER AND COPPER ALLOY MILL PRODUCTS

Anaconda American Brass Company

CIRCLE 173 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

JULY 31, 1961

VOLUME 32, NUMBER 31

DEPARTMENTS:

INTERESTING TO NOTE 3
WHAT'S NEW IN RESEARCH 4
DEVELOPMENTS TO WATCH 8
POINTS OF VIEW 12
THE ENGINEERING WEEK 16
READER TO EDITOR 22
MEETINGS 23
FYI PERSONAL 24
HORIZONS 25
PRODUCT DESIGN 37
DESIGN FILE 45
SIGNIFICANT COMPONENTS 47
DESIGN LITERATURE 56
ADVERTISERS INDEX 62
READER SERVICE CARDS 63

FEATURED:

26 . . HOW TO HEAT AIR FOR TESTING . . . W K Moen
Selection tables for any temperature to 500,000 F

31 . . NONSTANDARD SPUR GEARS . . . E A Brass
Altering pressure angle offers center-distance freedom

34 . . CAN YOU IGNORE NUMERICAL CONTROL? . . . A P Langlois
Simpler control systems make large production savings possible

40 . . INEXPENSIVE PHOTODRAWINGS . . . B W Schobin
An easier way to make engineering drawings from photographs

42 . . REGULATE THE EXHAUST ON AIR CYLINDERS . . . B A Boggs
Control back pressure offers new control versatility

44 . . STRENGTH OF METAL-POWDER PARTS . . . R E Talmage, H L Kee
It can be determined by simple hardness measurement

45 . . DESIGNING FLAT SPRINGS . . . W Griffel
Unit resilience and spring rate of 8 types

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MECHANICAL:

8 . . Engines to replace refrigerant expansion valves?
11 . . Mock moon proposed for product testing
47 . . O-rings seal oil-filled synchronous motor

ELECTRICAL:

8 . . New encapsulant promotes heat transfer
11 . . Nylon plugs designed for printed circuits

PRODUCTS DESIGNS:

37 . . Trailing wheels record ground condition
38 . . Mounting-plate manifold eliminates piping
39 . . Hanging drum swings to discharge

MATERIALS:

4 . . Polyester film use may be limited by alcohols
4 . . How hydrogen affects high-temperature materials
11 . . Heat-resistant sintered copper appears behind Iron Curtain

PROCESSES:

4 . . Gel-time meter works by plop
8 . . Explosion forming aided by molten metals
17 . . New ceramic applications promised by additive

GENERAL:

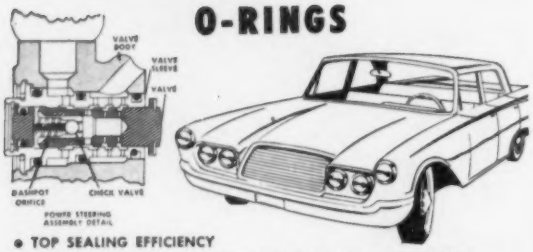
16 . . Repeat suborbital flight to prove out design changes
20 . . US firm licenses Soviet patents worth $50 to $100 million

THE COVER . . .

Hot-air testing is a practical and economical method for reaching temperatures to 500,000 F. To point up the article in this issue on selection of the method for testing, North American Aviation, Inc, has provided our cover pictures including an exclusive picture of GAM-77 Hound Dogs carried under the wings of a B-52 bomber in flight. Other pictures show actual hot-air test of the missile itself and another setup for testing the instrumentation compartment of the Minuteman missile. The terminal heating method and others are compared in Walter Moen's article beginning on page 26.

MINNESOTA MR RUBBER — SEALS *for Every Requirement!*

O-RINGS



- TOP SEALING EFFICIENCY
- HIGH DENSITY • WEAR RESISTANT • CUSTOM COMPOUNDS

INJECTION MOLDED O-RINGS

. . . give better service in any application

Minnesota Rubber injection molded O-rings always perform more efficiently and have a longer service life than ordinary O-rings because they do not have any variations in cross-sectional thickness.

In addition, the higher, more uniform density of rubber makes them highly resistant to chemicals and wear due to abrasion.

MR O-rings can be furnished out of the economical, yet durable industrial standard compound 366Y, or if your application requires it, Minnesota Rubber engineers will come up with a customized compound that exactly fits your needs.

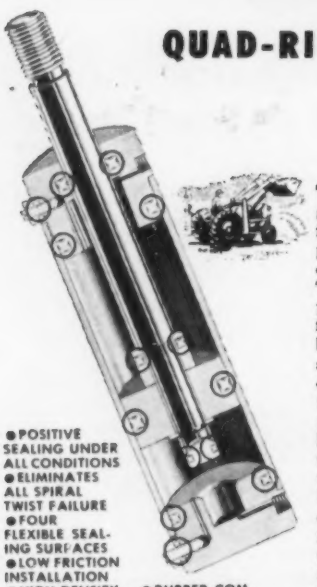
KAPSEALS®

LONG LIFE LOW FRICTION SEALING

The KAPSEAL® is a Teflon® boot which is used in combination with a standard O-Ring to give superior sealing performance and eliminate breakout friction. It comes in two styles, KIN and KEX. KIN is used in applications when the ID of the seal is the sealing surface, while KEX is used when the OD is the sealing surface.

A seal of this nature was needed for applications which involved long periods of time on stand-by or in storage, as well as applications requiring continuous, non-failing operation. Tests lasting over 4 million cycles give a good indication of the KAPSEAL's potential.

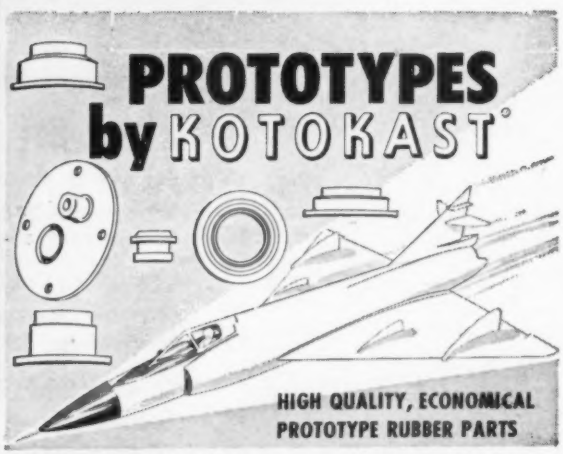
QUAD-RINGS®



- POSITIVE SEALING UNDER ALL CONDITIONS
- ELIMINATES ALL SPIRAL TWIST FAILURE
- FOUR FLEXIBLE SEALING SURFACES
- LOW FRICTION INSTALLATION
- HIGH DENSITY INJECTION MOLDED
- RUBBER COMPOUNDS TO FIT APPLICATION

The MR QUAD-RING gives superior sealing performance in hydraulic and pneumatic applications, either static or dynamic. The four lipped design prevents the rolling effect found with O-rings, thereby eliminating the common spiral twist failure. This exclusive design features four flexible sealing lips and permits installation with less squeeze, reducing friction, breakout force and wear. QUAD-RINGS can be made out of rubber compounds which exactly match the application. You can be sure of positive sealing when you use QUAD-RING SEALS in all your installations.

PROTOTYPES by KOTOKAST®



CLOSE TOLERANCES—Tolerances are identical with those that will be found on standard production parts.

FAST SERVICE—Usually it will take only hours from the time the order is received to produce twelve prototype parts using PROTOTYPES by KOTOKAST.

ECONOMY—This is the most economical method of producing prototype parts there is.

NO LIMITATION—PROTOTYPES by KOTOKAST has been successfully applied to a wide variety of designs ranging from a simple washer to intricate molded parts.

FOR MORE INFORMATION ON . . .

QUAD RINGS®. . . KAPSEALS®. . .

O-RINGS OR PROTOTYPES BY KOTOKAST

WRITE

MINNESOTA MR RUBBER

DEPARTMENT 259 • 3630 WOODDALE AVENUE

MINNEAPOLIS 16, MINNESOTA

PRODUCT ENGINEERING ELMER J TANGERMAN *editor* CHARLES S MILL *publisher*

ROBERT W CARSON *managing editor*
RICHARD M KOFF *assistant managing editor*

ROBERT E ABBOTT *senior associate editor*

JOHN KOLB *associate editor*
NICHOLAS CHIRONIS *associate editor*
ANNESTA R GARDNER *associate editor*
WILLIAM GILMAN *associate editor*
FRANKLIN D YEAPLE *associate editor*
JOSEPH J KELLEHER *associate editor*
DOUGLAS C GREENWOOD *associate editor*
CHARLES J LYNCH *associate editor*

BENEDICT A LEERBURGER, JR *assistant editor*
DORA K MERRIS *assistant editor*
HERBERT KEE *assistant editor*
FREDERICK MARICH *assistant editor*
FRANK HALL *assistant editor*
BRUCE H FRISCH *assistant editor*
ANITA CAMERIK *assistant editor*

RICHARD E ROOMAN *art director*
E G LOADER *associate art director*
ANGELA M GIACIN *assistant art director*

NORMA J VAN NESS *production supervisor*
LILLIAN M WITHAM *assistant supervisor*

ROBERT E BRUCKNER *consulting editor*
DOUGLAS GREENWALD, *mgr, economic svces*
C C KANE *reader service manager*

REGIONAL EDITORS

FELIX GIORDANO *Detroit*
SETH PAYNE *Washington*
WILLIAM B WALLACE *Los Angeles*

ARTHUR ERIKSON *Paris*
GENE DI RAIMONDO *Milan*
RAYMOND SHAH *Zurich*
FRED BAER *Vienna*
NICHOLAS LANDON *London*

McGRAW-HILL NEWS BUREAUS

JOHN WILHELM *director*
MARGARET RALSTON *associate director*

GEORGE B BRYANT, JR *Washington*
DONALD MacDONALD *Detroit*
ARTHUR ZIMMERMAN *Cleveland*
STEWART C RAMSEY *Chicago*
BRUCE CROSS *Chicago*
JENNESS KEENE *San Francisco*
KEMP ANDERSON *Los Angeles*
RAY BLOOMBERG *Seattle*
B E BARNES *Atlanta*
MARVIN REID *Dallas*

JOHN SHINN *London*
JOHN TUNSTALL *London*
ROBERT FARRELL *Paris*
CURT AGREN *Stockholm*
ERNEST CONINE *Moscow*
PETER FORBATH *Bonn*
JIM MORRISON *Bonn*
SOL SANDERS *Tokyo*

A McGRAW-HILL PUBLICATION
July 31, 1961
Vol. 32, No. 31
Executive, Editorial, Circulation and Advertising Offices:
330 West 42nd St., New York 36, N. Y.
Telephone: LOngacre 4-3000
Teletype: TWX NY 1-1636
Cable Address: McGRAW-HILL, NY

PRODUCT ENGINEERING is published weekly by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), founder. US subscription rates for individuals in the field of the publication, $3 per year, single copies 50 cents; Canadian subscription $5 per year; foreign $25 per year, payable in advance. Printed in Albany, NY; second-class postage paid at Albany, NY. Title ® registered at US Patent Office. ©Copyright 1961 by McGraw-Hill Publishing Company, Inc. All rights reserved, including the right to reproduce the contents of this publication, either in whole or in part.

UNCONDITIONAL GUARANTEE. The publisher, on written request, agrees to refund the part of the subscription price applying to the remaining unfilled portion of the subscription if editorial service is unsatisfactory. PRODUCT ENGINEERING articles are indexed in both the Applied Science and Technology Index and the Engineering Index. PRODUCT ENGINEERING publishes its own semi-annual index. Copies are obtainable on request to the editor.

POSTMASTER Please send form 3579 to Fulfillment Manager, PRODUCT ENGINEERING, 330 W. 42nd St., New York 36, NY.

INTERESTING TO NOTE

first flight

When Benjamin Franklin was our emissary to France, in 1783, he witnessed a scientific first—one which must have pleased scientist Franklin immensely. On November 21, Jean Francois Pilatre de Rozier and the Marquis d'Arlande climbed into a balloon, filled it with hot air, and took a 20 minute, 5½ mile trip across Paris. (For an article on hot-air heating, see p. 26.) Although de Rozier made the first recorded human balloon ascent 5 weeks earlier, this was the first "aerial voyage."

Balloons were first thought of only as an answer to man's quest for flight but they soon were being used to solve other scientific problems. Victor Hess deduced the existence of cosmic rays (as they were later named) from electrical effects that were intensified the higher he went. Adventurous balloonists learned about the migratory nature of the weather by following air masses. Recently plastic balloons served as high altitude observation platforms and enabled astronomers to observe light from certain planets unfiltered by the earth's atmosphere.

The cloud physicist has also found the balloon a valuable research tool. The speed and motion of most aircraft make observation of microscopic cloud droplets difficult. Captive, constant-level and free-floating balloons allow much more thorough study of rain generation and thundercloud electricity.

photography's early days

Samuel F. B. Morse is credited not only with the invention of the telegraph but he also had a worldwide reputation as an artist. In fact it was while in Paris, studying and painting, that Morse learned of an invention that would become even more famous than his revolutionary system of communication. In the spring of 1839, Morse visited the laboratory of French inventor L J M Daguerre. There he saw a process for recording, on a plate, pictures "as exacting" as on a painter's "canvas." Although Daguerre kept the secret of his process, Morse, in a letter to the New York *Observer*, described what he had seen, calling the pictures, "Rembrandt perfect."

As soon as Morse returned to America he saw to it that Daguerre was elected an Honorary Member of the National Academy of Design. By fall Daguerre's process was revealed before the Academy of Science in Paris. In no time amateur photographers were studying the method.

Although instruction manuals were available, the only way really to master the technique was with personal instruction. Francois Gourand, Daguerre's student and sales agent for his equipment, came to America to give lessons. The process was quite complicated, requiring several boxes of light sensitive chemicals, a heat source, water and a strong stomach—the fumes were quite pungent. At first, exposure times were too long for practical portraiture—a daguerreotype of King's Chapel, Boston in 1840 required an exposure of 40 minutes. Morse, however, was able to make a portrait by subjecting members of his family to the ordeal of sitting motionless in the hot sun with closed eyes for 10 to 15 minutes. He also believed flour applied to the face would improve the shot.

Library of Congress

A photographic copy, by Mathew Brady, of a daguerreotype of Louis Daguerre. Taken in France, 1848.

Within months, improvements were announced. Josef Petyual of Vienna designed a lens which admitted 16 times more light. John F. Goddard in London increased the sensitivity of the daguerreotype plate by fuming it with chlorine as well as iodine.

Photography moved quickly. By 1850, pictures were taken on the high seas as well as in operating rooms. The daguerreotype process gave way to new and better techniques. Today, you can take your picture and have a print in less than ten seconds. For engineers, photography has long been a valuable aid. On page 40, an article tells how photodrawings can now be used to save time and money.

WHAT'S HAPPENING IN RESEARCH . . .

Alcohols may limit polyester film use

Applications for polyester film in some areas may require re-examination as a result of a GE study of the effects of alcohols on it.

The tests were aimed at finding a suitable antifreeze (to prevent capillary freezeup) for hermetically sealed refrigerator and air conditioning systems using acrylic-coated magnet wire, polyester film wrapping and polyester lacing cord as stator insulation. And, C. J. Bushouse of GE told the ASHRAE, they show that methanol not only attacks the polyester film; but, at elevated temperatures, degrade it to the point of embrittlement.

Tests of other primary and secondary alcohols and antifreeze compounds showed similar results. Tertiary alcohols did not seem to attack the film. But they are not very good antifreezes. Bushouse's conclusions: none of the compounds is suitable for use with polyester film insulating systems and the use of anti-freeze in refrigeration systems of this type is not recommended.

Gel-time meter for resins, adhesives works by plop

A lead sinker suspended by a wire from a motor-driven lever arm provides a neat indication of the time it takes a liquid to gel.

The device, a "gel-time meter" designed for laboratory use, is arranged to drop the weight into the liquid at 60-sec intervals.

When the lever reaches the bottom of the stroke, a microswitch activates a counter, resets the timer, and reactivates the cycle. But the weight of the sinker is chosen so that it will not sink to the bottom in the 30-sec drop time when the liquid starts to gel. Thus, the switch is not activated, and the instrument stops, providing a record on the counter of the number of cycles (minutes) it took for the liquid to turn into a semi-solid.

The sinkers are of the standard bass-casting variety (#9 for clear resins with viscosities to 75,000 cp; #5 for thixotropic and filled resins.

The instrument is about 4 by 5 by 12½ in. high, weighs 8 lb. The price $97. Mol-Rez Div, American Petrochemical Corp, 3134 California Street, NE, Minneapolis 18, Minn makes it.

How hydrogen affects high-temp materials

Oxidizing atmospheres are not the only hazard faced by refractory materials at ultrahigh temperatures. Hydrogen may be even more damaging.

A recent study at Lewis Research Center of performance of borides, carbides, and nitrides in a hydrogen atmosphere at 4500 to 5000 F shows tungsten and tantalum boride and columbium carbide do very well. But some compounds, like hafnium carbide, known to be stable in air, show a serious weight loss—definite evidence of a hydrogen reaction. Most of the nitrides tested, too, (HfN, TiN, ZrN) proved not to be stable above 4500 F in hydrogen.

An earlier study (now available as NASA memo 5-59-E) showed many of these—including hafnium, molybdenum and tantalum carbides, hafnium and zirconium carbide to be stable below 4500 F; so this may be the critical temperature for hydrogen atmosphere use.

The new report will be available free of charge to government contractors from NASA as TN-D-844. Others may obtain copies through OTS, Dept of Commerce, for 50¢.

Exotic lubes under study in USSR

To enlarge the choice of lubricants for high-pressure forming, Soviet engineers are amassing data on shear stress of Armco iron, magnesium, silver chloride, and other unusual materials at pressures to 500,000 atmospheres.

Up to 100,000 atmospheres, they say, magnesium and silver chloride have shear values well above graphite. But shear stress of graphite increases sharply above that point, while the other two continue their linear increase, so that, at very high pressures the differential is much less; and silver chloride, at least, may prove superior to graphite. A report on the tests appeared in *Doklady, Akademiya* nauk SSSR, v.134 #4, p 787-B.

(Note: For more on unconventional lubricants, see *PE*—Apr 24, p 6, May 1, p 6 and May 8, p 8.)

briefs . . .

Transition-temperature changes are the most detrimental effects of neutron irradiation on mechanical properties of steel, say L. E. Steele and J. R. Hawthorne of Naval Research Lab. And this effect is almost constant, regardless of radiation temperature, up to about 450 F. At 500 F, though, the trend line shifts a bit, and the metal seems able to stand slightly higher levels of irradiation—perhaps owing to minor thermal annealing. Results have been plotted on several types of steel, and tests continue.

More high-purity metals—this time, zirconium, thorium, and columbium—are being made available for research. (For news of others, see *PE—June* 12, p 6.) This trio, all in crystal bar form, and with total impurities of less than 700 ppm (less than 300 for the zirconium; barely 120 for the thorium) are now being produced by Metal Hydrides, Inc, Beverly, Mass, are available at approximately $5/gm. Data sheets show the high-purity metal has an electrical resistivity of 12.5 microhm-cm for Cb, 40 for Zr, and 19 for Th; with melting points at 4532 F, 3380 F, and 3074 F. (The first two above those of "standard" materials; the third, below.)

New paints and primers, and perhaps new bonding agents and fluxes, are forecast as Esso Research seeks to put its oil additive technology (and productive capacity) to work. It would solve a good many oil industry problems, Esso thinks, if new ways could be found to use these anti-oxidants, corrosion-inhibitors and wetting agents; and it's confident the job can be done. Already under investigation is use of these compounds to improve bonding of paints to metal surfaces; and other projects are planned. —ARG

SINGLE WORM

HELICAL-WORM

LINK-BELT fan-cooled worm gear speed reducers...

the compact way to achieve high-hp, high-ratio reduction

DOUBLE-WORM

3 BASIC DESIGNS . . . WITH MANY VARIATIONS! Link-Belt worm gear speed reducers are the space-saving, economical answer for every right-angle speed reduction job. You have your choice of industry's *most complete* range of types, ratios, and sizes . . . in single and double reductions . . . with many combinations of input and output shaft arrangements.

Fan-cooling is the key to the exceptional compactness of this high horsepower, high ratio line. An aluminum radial fan directs a steady flow of cooling air over the finned sides of the housing. This assures maximum heat dissipation . . . permits high horsepower, high ratio reductions in minimum space . . . pays off in lower initial cost for each center distance.

Other features include: rugged, carefully machined housings; automatic splash lubrication; durable centrifugally cast bronze-alloy gears; hardened, ground and polished nickel-steel worms; high-capacity roller bearings.

ASK OUR FIELD ENGINEERS to help you with your application problems. They will specify the speed reducer that *exactly* matches your needs. With industry's most *complete* range of types and sizes to work with, their recommendations are unrestricted, unbiased. Contact your nearest Link-Belt office. Ask for Book 2824.

15,678

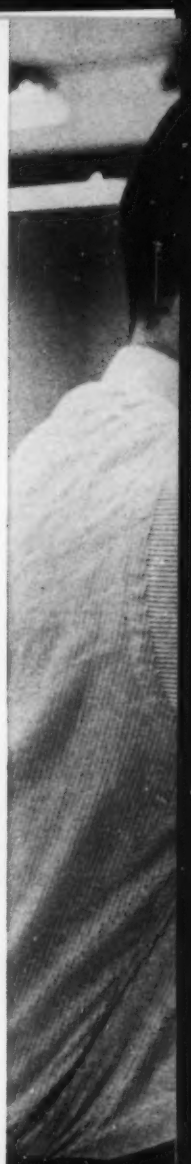
LINK-BELT

SPEED REDUCERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13) South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World.

IT'S NEW IT'S FROM BRUNING

Five Hundred TRACING PAPER



Here is a new drawing medium truly worthy of your attention. Bruning's Five Hundred is a tracing paper *engineered* for draftsmen—developed after a decade of testing and proving by America's leading supplier to the engineering profession.

Five Hundred tracing paper has all the qualities that valuable drawings need and deserve. More, it has them in outstanding degree: the translucency, the permanence, the surface texture (each side slightly different for individual preference).

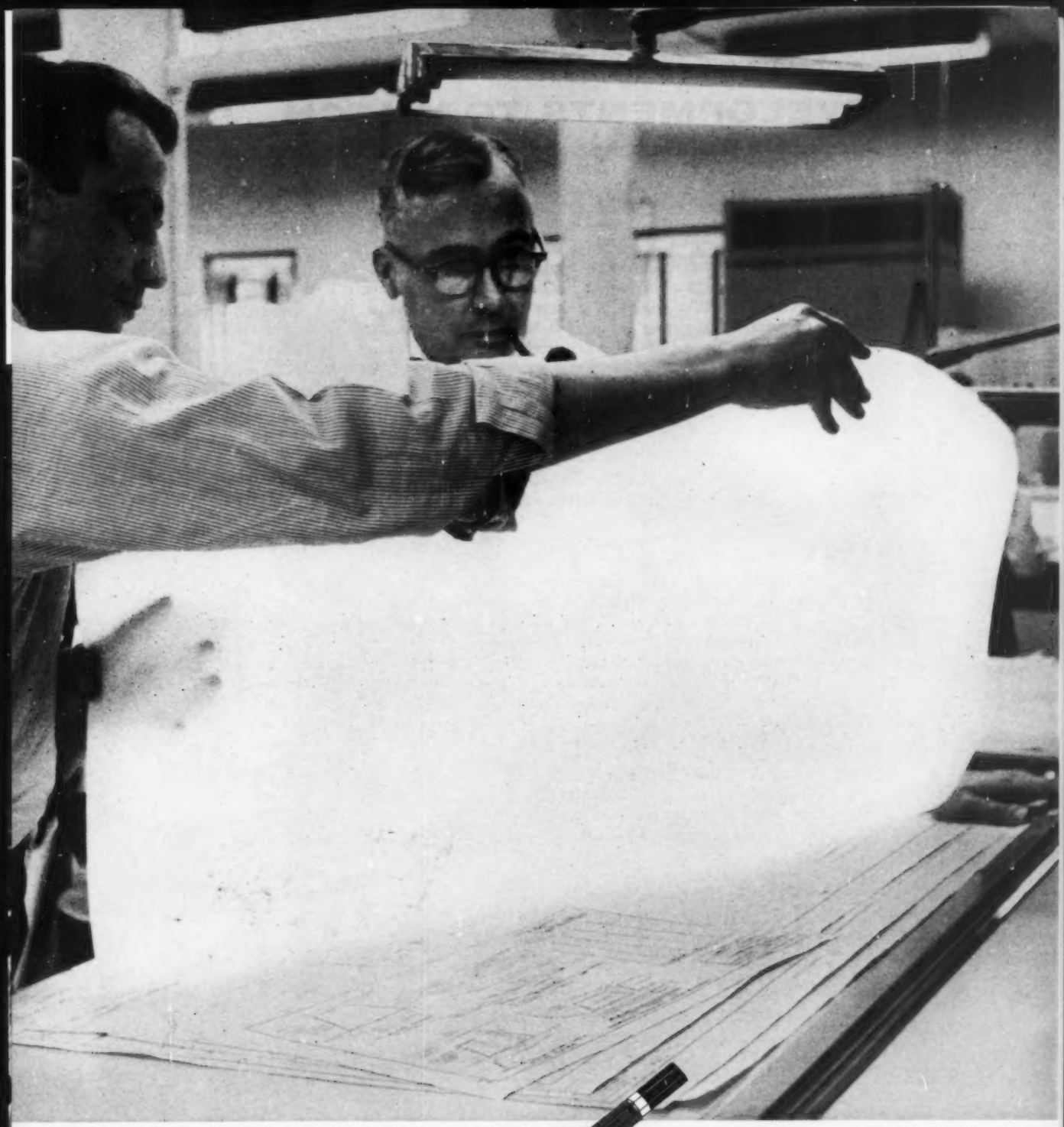
Today, with the costs of engineering drawings higher than ever before, the paper on which they're made should be the best obtainable—and the best is Bruning Five Hundred. Yet, this new drawing medium costs no more than conventional tracing papers.

TRY IT...PROVE IT

The real proof of this new tracing paper is, of course, your own test. So confident are we that Five Hundred will meet your highest expectations, we offer a large trial supply well below our cost. You have your choice of roll or sheets: simply mark the coupon.

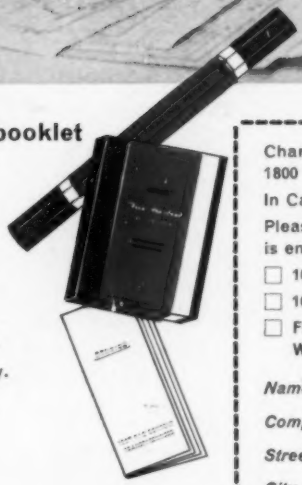
BRUNING

CIRCLE 6 ON READER SERVICE CARD



special offer: trial supply plus informative booklet

- **JUST ONE DOLLAR** brings you the new Five Hundred in your choice of a 10-yard roll (36" wide) or 100 sheets of 8½ x 11—each sells for approximately $3.00.
- **AND YOUR FREE BOOKLET!** In the course of developing the new Five Hundred, Bruning researchers turned up many facts of real importance to all who use tracing paper. These helpful pointers are yours in a handy guidebook, *"Tracing Paper Characteristics, and What They Mean to You."* It makes interesting reading. Check the box for your free copy.



Charles Bruning Company, Inc. **PE-7**
1800 Central Road, Mt. Prospect, Illinois
In Canada: 103 Church St., Toronto 1, Ontario

Please send materials I have checked below. My dollar (s) is enclosed.

- ☐ 100 sheets Five Hundred tracing paper, 8½ x 11 ($1.00)
- ☐ 10-yard by 36" roll ($1.00)
- ☐ Free guidebook, "Tracing Paper Characteristics, and What They Mean to You"

Name..... *Title*.....

Company.....

Street.....

City..... County..... ...*State*.....

DEVELOPMENTS TO WATCH...

Molten metals aid explosion-forming

Asymmetrical nozzle shapes have been successfully explosion-formed in tungsten using molten metal as the energy-transmission medium, I. Lieberman of Aerojet-General reports, and the system seems applicable to a wide variety of refractory metals. For tungsten, molten aluminum at 1800 F serves as the forming bath (in place of the water normally used) and acts as a heat-transfer as well as a liquid energy-transmission medium. The process is still in its early stages of development, and there are still a good many questions to be answered. But, says Lieberman, "the system has already demonstrated its ability to permit explosive forming to be used under conditions of elevated temperatures while permitting close control over the transmitted explosive pressures."

This encapsulant promotes heat transfer

A high-density dispersion of alumina in an inert liquid can provide a high degree of thermal conductivity to aid heat dissipation in electronic equipment, Philco researchers report.

Such a dispersion, inserted between a transistor and its case can increase heat transfer by a factor as great as 2 to 1.

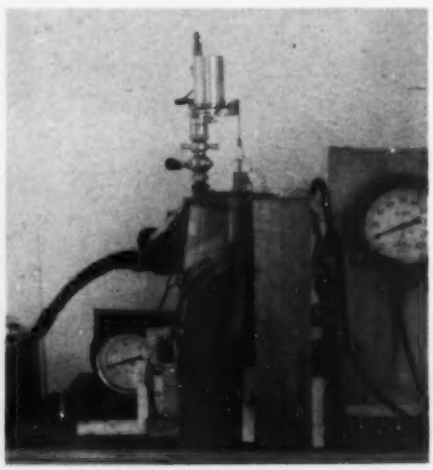
The trick is to get the density of alumina particles high enough to provide a conductive path through the liquid; and also, in effect, to hold it together, preventing undue thermal expansion and permitting the dispersion to serve as a cushioning and vibration-damping medium. Particle size and shape must also be carefully chosen. (Two sizes are used—one large and one small, to fill the voids between the larger particles.)

For the fluid, Philco is now using a polysiloxane, though others are under test; and special means are being developed for mixing and metering the dispersion.

Engines to replace expansion valves?

Can an expansion engine replace the refrigerant expansion valve in vapor compression cycle refrigeration systems? Use of an isentropic expansion system in place of a throttling valve could bring an increase in performance of at least 10% in systems with 50% efficiency; even higher for more efficient systems. The idea is not new, but very little data is available to guide the choice.

To fill the gap, Convair and SMU engineers built the test set-up shown here, using a modified single-cylinder refrigeration compressor with $1\frac{7}{8}$-in. bore and stroke. It has a wooden flywheel (see photograph) with a slide-and-crank mechanism that serves as the reducing motion for the engine indicator.



TEST ENGINE, modified for isentropic expansion studies has wooden flywheel which acts as a cam shaft to open and close the microswitches that control the solenoid valves which are placed at the compressor inlet and discharge ports.

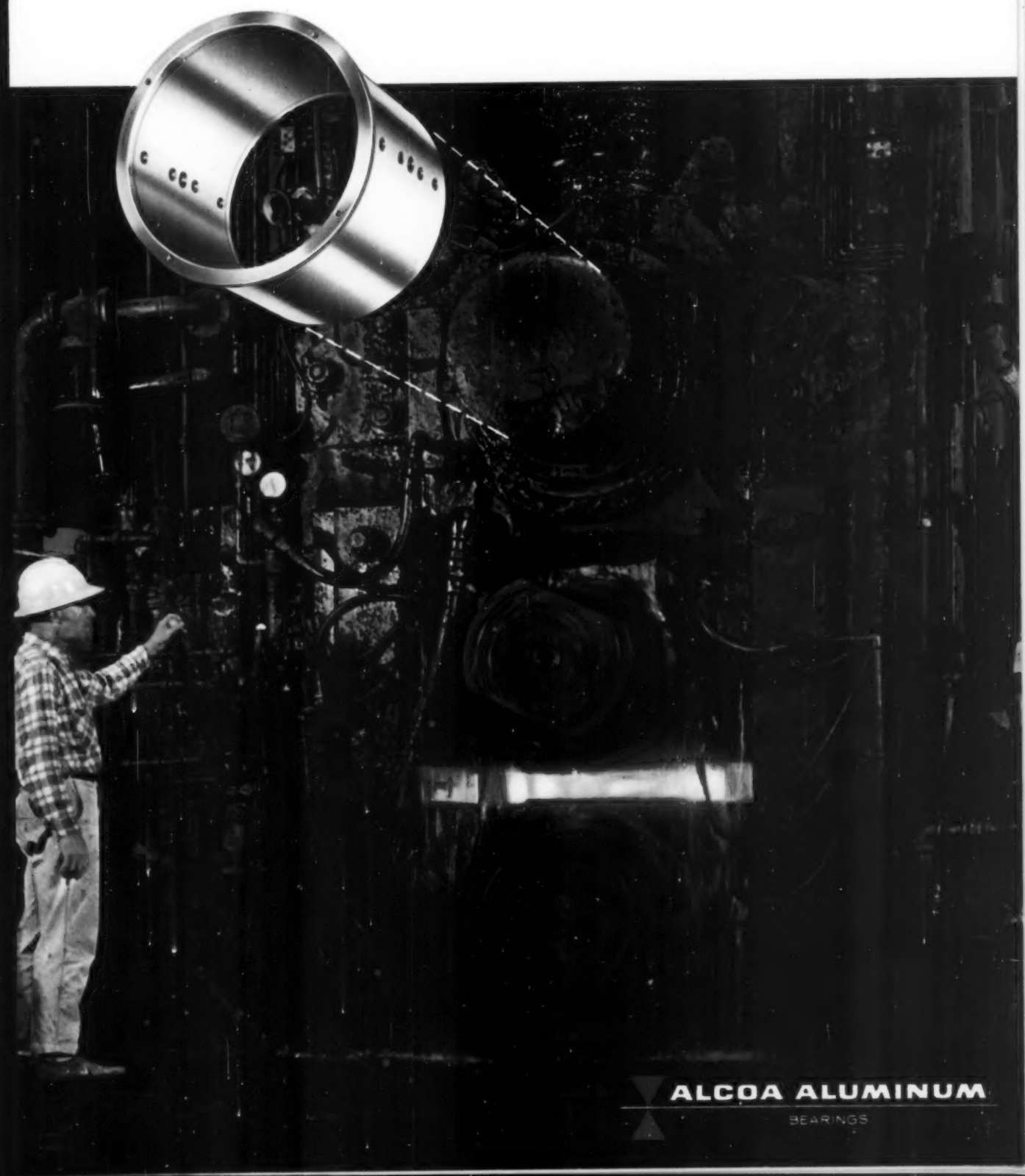
To operate the engine, high-pressure liquid refrigerant is fed through the unit and allowed to expand to a low-pressure source. Several runs have been made, varying inlet valve angles and supply pressure, with engine speed ranging from 45 to 71 rpm. A recent report to the ASHRAE noted that indicated horsepower ranged from 3.30×10^{-6} to 5.7×10^{6} and enthalpy change from 0.0621 to 0.0980 btu/lb.

Although isentropic energy recovery was only 10%, T. M. Olcott Convair senior propulsion engineer, believes improvement in engine valving could boost that figure to 40%, and that further work is justified.

continued on p 11

CIRCLE 9 ON READER SERVICE CARD→

When an aluminum bushing takes a 5-million-pound load...

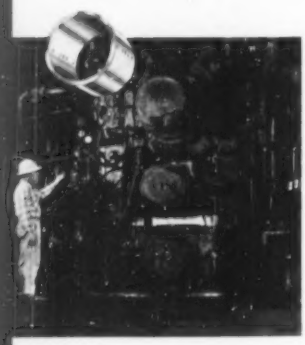


ALCOA ALUMINUM

BEARINGS

When an aluminum bushing takes a 5-million-pound load...

that's Alcoa Total Ability at work!



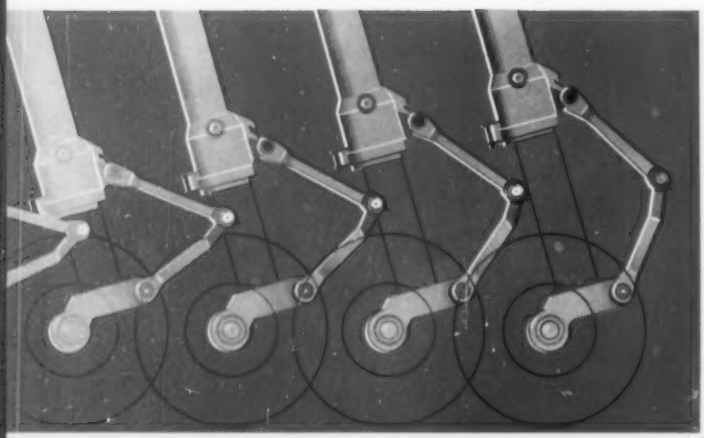
And when tandem cold mills roll steadily at 5,000 fpm, that's even more impressive! Yet, this is only par for the course with aluminum. In steel mills both here and abroad, aluminum bushings have proved themselves in the most exacting applications. Laboratory tests prove that aluminum bearing alloys carry *higher unit loads at higher speeds than any other material.*

Morgoils, made by the Morgan Construction Company, Worcester, Mass., are bearings of exceptionally high load capacity. They range in size from 7 to 53 in. journal diameter, have standard load capacities from 90,000 to over 5,000,000 lb! Because they use aluminum alloy, these bushings are unaffected by corrosive additives in oils.

No one knows more about aluminum bearing alloys than Alcoa. And *Alcoa Total Ability* means you get direct help—whether you're designing a new bearing, bushing . . . or placing a finished unit in the line. For details, call your nearest Alcoa sales office. Or write: Aluminum Company of America, 857-G Alcoa Bldg., Pittsburgh 19, Pa.

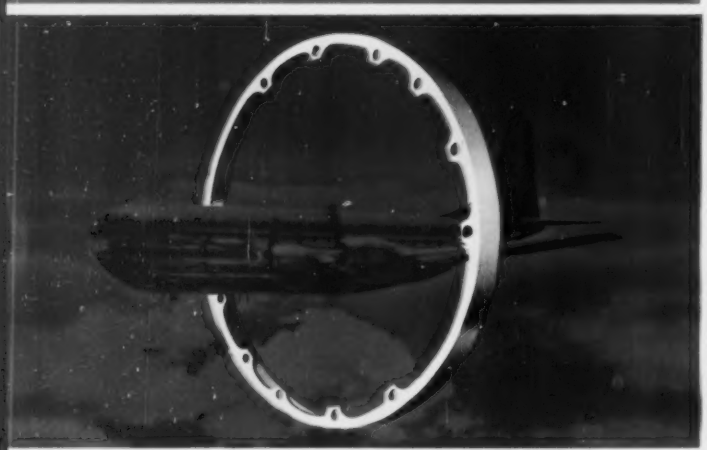
ALCOA ALUMINUM

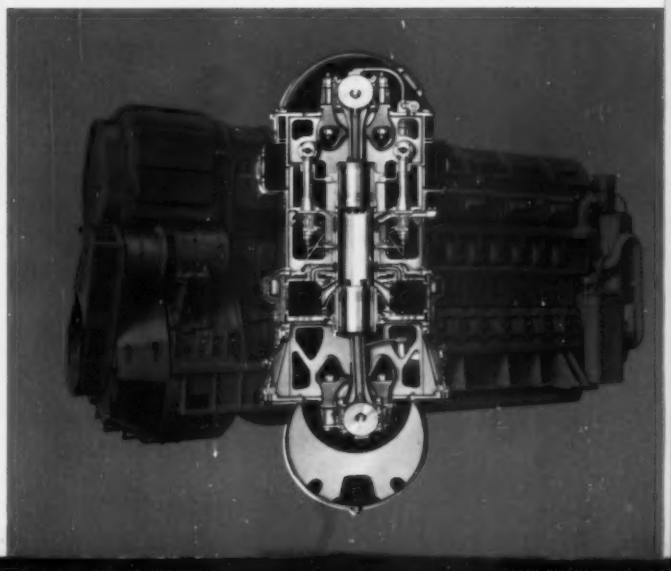
BEARINGS



ALCOA
TOTAL ABILITY
GIVES YOU
BEARING ALLOYS
WITH OPTIMUM...

- Embeddability
- Heat Conductivity
- Corrosion Resistance
- Long Life
- Compatibility
- Protection for Adjacent Parts
- High Load-Carrying Ability
- Ability to "Take It" at High Speeds





Heat-resistant sintered copper appears behind Iron Curtain

The Soviet bloc claims sintered copper alloys containing oxides of aluminum, magnesium, and silicon that show an oxidation resistance superior to copper itself, are stable at least to 1300 F, and show surprisingly high electrical conductivity (75 to 95% that of pure copper). These are mixtures of copper powder with oxides of aluminum, magnesium, and silicon in amounts from 1 to 5%. A report in the Hungarian monthly *Technika* attributes the development to USSR metallurgists and says the alloys are also half again as hard as copper over their full temperature range, and can be pressed and sintered very close to maximum theoretical density.

The Hungarians aren't saying exactly where the work was done, but give surprisingly complete data on nearly a dozen alloys. Best results from the standpoint of conductivity seem to have been obtained with magnesia additions. The 1% magnesia alloy had a conductivity of 94.5%, and even the 5% alloy showed 82.4%. The alumina alloys were harder, however. Combination alloys have also been tested—with optimum total oxide content being pegged at 7 to 13%.

British boost properties of powdered steel

Sintered steel with a tensile strength close to 150,000 psi and a minimum elongation of 4% is claimed by Metal & Plastic Company, Ltd, Birmingham 11, England (a member of the Birmingham Small Arms Group). Pawls and ratchets made by the new process are said to show great wear resistance as well as strength; and, M & P says, they're competitive in cost with fully heat-treated solid steel. Parts are produced at a single pressing and sintering operation—and require no heat treatment to develop the guaranteed properties. They can, however, be hardened (by cyanide or nitrate treatments) if desired.

Mock moon proposed for product testing

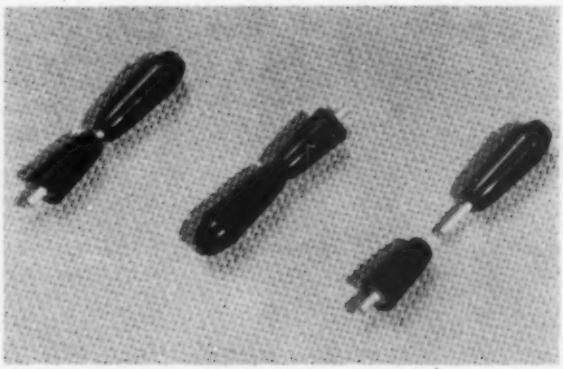
A lunar simulator, to test everything from transistors to tractors, is proposed by Army Engineers, who fear that "know-how needed 10 years from now may not be available for 20" unless we get started now. Conditions on the moon are quite different from those in space, they say. Conduction, reflectivity and other problems connected with the lunar surface make simulated tests a necessity.

In the latest proposal, the simulator will be a dome about 10 meters high and 10 meters in dia, with a vacuum system built into the walls. Solar radiation would be reproduced by high-pressure xenon lamps in the ceiling. To establish temperature control, the walls would be mounted with a liquid nitrogen heat sink; the heat input of the xenon lamps would be dissipated through the walls' heat sink, allowing the extreme lunar temperatures (plus 212 F to minus 270 F) to be simulated.

The magnitude of the construction problem for such a simulator is indicated by the fact that specific sets of conditions will probably have to be maintained for a minimum of 15 days (the length of a lunar day and night). USAERDL estimates the construction cost at about $6 million, with at least half a million for structural design.

Nylon plugs designed for printed circuits

Miniature nylon-insulated plugs and sockets are being introduced by the Radio Div of AEI, London SW1. Diameter of both plug and socket is 0.19 in., permitting them to be mounted on 0.20 in. centers. Pin dia is 0.05, to fit standard mounting holes. Maximum length for the molded portion of the plug is $\frac{7}{8}$ in. The socket is $\frac{11}{16}$ in. AEI will mold them in red, black, or blue. Pins are silver-plated brass. AEI says they'll be "particularly suited to printed circuit mounting." —ARG



THE QUESTION:

Has Detroit lost its design leadership to European manufacturers?

GIUSEPPE ROVELLI, engineer and executive, Tire Div, Pirelli S.p.A. of Milan

"Detroit was once the ultimate . . . in car design. I felt this as a boy when the American car was different in engineering, concept and design from the European one. Because of the specific conditions prevailing on the American car market, the manufacturers in Detroit had to incorporate in their cars the most advanced technological and design features. This trend seemed to continue also in the period immediately following WW II. After 1950 however, the balance tipped in favor of the European manufacturers. The rebirth of the European car industry, and the trend which it has been following since, was greatly influenced by the so-called Italian line. This line first conquered the manufacturers of sport cars and gradually spread to the builders of standard cars from Fiat to such conservative manufacturers as the BMC of England. Thus, what characterizes the design of European cars today is a sober and harmonious line adhering strictly to the mechanical structure of the car.

"Meanwhile Detroit moved on what seemed an entirely opposite course. Indeed, Detroit developed the bigger and larger and more powerful and more-chromium-plated cars. It soon found that the sales of European cars were growing at a pace indicative of a shift in taste of the average American car buyer. When this was clear Detroit decided to go into the manufacture of the compact car—which was definitely of European inspiration adapted to the needs and the conditions of the US car market.

"The European automobile industry in its infant stages learned a great deal from Detroit. From 1950 it took the lead and imposed its views upon American industry. Today, however, the interdependence and mutual influences are so great that it is difficult to assign the final share to one or the other industry."

GENE BORDENAT, vice president and director of styling, Ford Motor Co

"If anything, the reverse is true . . . the majority of European carmakers have adopted or adapted elements of American car styling. Until shortly after WW II, European cars generally fell into one of two categories—the limited-volume custom car, or the vehicle produced in some quantity and with an emphasis on functionalism almost to the exclusion of appearance aspects.

"Since the war, though, mass production techniques have been applied more and more in the European automotive industry. And the considerations these techniques involve have become more obvious in the appearance of many European production cars. It is largely among these cars that the influence of American styling can be most readily seen, as witness such vehicles as the Fiat, Lancia Flaminia, Opel Rekord and Peugeot 404. Of course, the European custom car still exists. And, by and large, its styling is quite provocative. This is so mainly because of the presence of features made possible as a result of the dimensional liberties taken by custom-car stylists. However, most of those features are impractical for use in American production cars, if only for reasons of cost.

"Leadership, by definition, requires followers—not merely a handful but a great many. The American automotive industry has that following, and I see no immediate danger of its losing it."

PHILIPPE CHARBONNEAUX, industrial designer and consultant, Renault, France

"Detroit already lost leadership . . . however, Detroit can regain the key position in automotive design if it is willing to change some of its concepts. I don't believe the design of American and European cars can be compared at the moment—there is too much difference in size and horsepower. Even the American compacts, anywhere from 14 to 16 ft long, powered by engines that in France are rated between 15 and 20 fiscal hp, are big in the automotive context of Europe where most of the cars produced are less than 13 ft long and have motors with 2 to 7 fiscal hp ratings.

"Another factor prevents a direct comparison of American and European designs. That is the tendency now current in Europe to return to aerodynamic lines as a means to cut down gasoline consumption and get higher speeds from small engines. The tendency forces the European style to rounder, more supple lines, especially for the frontal surfaces. In America, this factor isn't important and a more-varied style is possible.

"Europe, in fact, is at a design disadvantage. It's much more difficult to create esthetically elegant forms when cars have short over-all length since the interior height has to be kept practically the same as that of a long car. I'd even go so far as to say that the longer a car is, the lower it can be; the seats can be tilted back a little more and the roof line lowered."

OTTO HOEHNE, production manager, Volkeswagenwerk, Germany

"There can be no yes or no . . . to this question. Design and engineering are not isolated within national boundaries, they are ideas, and ideas are free of such restrictions. What is developed in England soon becomes known in Italy where, more than likely, something is added to the original idea. What an American develops soon becomes part of the common warehouse of knowledge in Germany and elsewhere. Nations that trade goods also trade ideas on the mutually beneficial two-way street of commerce. This is why trade is so important to progress.

"Detroit has not lost its design leadership to Europe any more than Europe has seized it from Detroit. No country can ever dominate such a complex field as automotive engineering. Design leadership is not something that is located in Detroit, today, in Coventry tomorrow, and in Wolfsburg the following day. It exists in varying degrees wherever automotive engineers live, work and travel. Detroit's engineers are among the world's best. They have shown their daring and imagination in the many new cars, completely new cars, that have been introduced in the past two years. These American compacts, with designs ranging from rear-engine air-cooled models to four-cylinder front engine with rear-mounted transaxle, are exciting evidence of Detroit's flexibility and talent.

"Let us remember that the automobile is an international commodity, the most international of all, being mobile in itself. Built into it is the best thinking of many brains of many nationalities."

WILLIAM L MITCHELL, vice president in charge of styling, General Motors Corp

"Detroit has in no sense lost . . . to European manufacturers. If anything, the reverse is true. Our designers who visit Europe regularly see more and more American influence in the cars shown at the annual auto shows.

"European car makers now are changing models more often, adopting two-tone interiors, using more chrome to brighten car decor, and using bright colors instead of traditional dark monotones. In short, they are spending more money on eye appeal. Look closely at the new European cars and you will see in many of them body silhouettes, wheels, roofs and other styling features which are American. Several manufacturers of small cars have actually copied the design of our Chevrolet Corvair.

"Interestingly, the American influence has even extended to basic techniques of car design. European styling studios are being patterned after ours. They are now using clay models and glass-fiber prototypes to develop new models. European carmakers are discovering what our American auto manufacturers discovered in the early 1930's—that people sense a monotony in sameness and, if they have sufficient purchasing power, they will buy the cars which are distinctive and tend to reflect an individual's personality."

CIRCLE 14 ON READER SERVICE CARD→

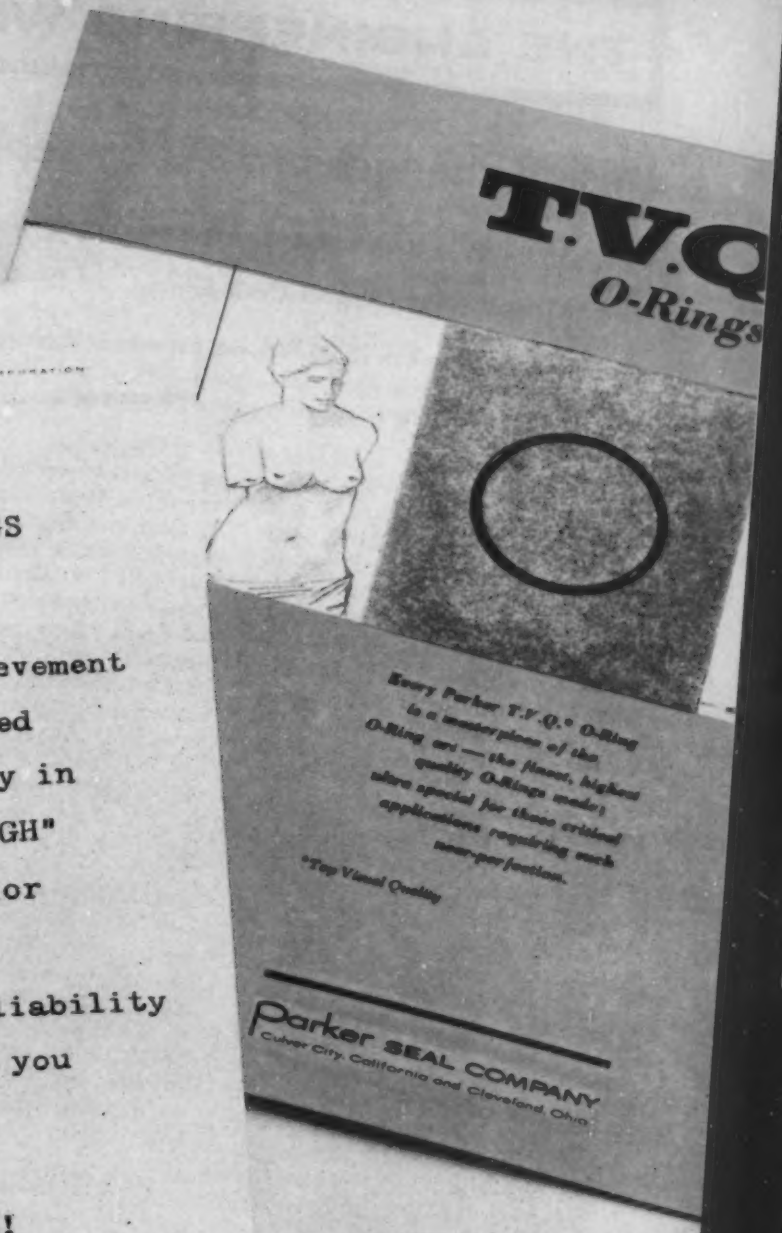
ANNOUNCING A
MAJOR ADVANCEMENT
IN O-RING
TECHNOLOGY!

Parker SEAL COMPANY

IMPORTANT ANNOUNCEMENT
TO ALL USERS OF MILITARY O-RINGS

In developing Parker T.V.Q.*
O-Rings a major technical achievement
has resulted in amazing improved
quality and greater reliability in
all O-Rings. This "BREAKTHROUGH"
enables Parker to offer superior
quality military O-Rings.
Compare Parker quality and reliability
with all other O-Rings before you
specify ANY O-Ring.

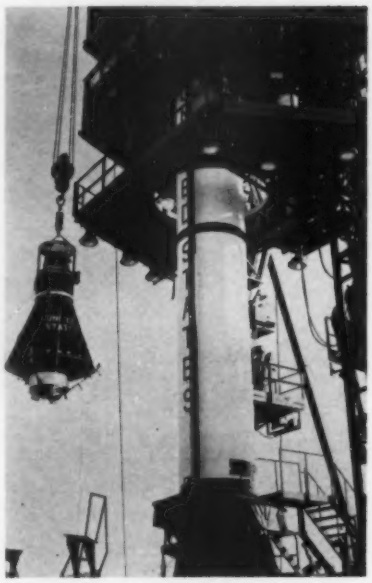
*Top-Visual Quality-
no finer O-Rings can be made!



Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio

Design changes proved by repeat suborbital flight

- **Liberty Bell 7 is forerunner of latest capsule destined to carry first American into orbit.**
- **Flight duplicates that of Cmdr Shepard and the Freedom 7 capsule.**
- **NASA, fully aware of the high-risk factor in duplicating Freedom 7 flight, says: "Each flight adds significantly, if not historically, to man's understanding of the strange environment of space.**



MERCURY-REDSTONE being joined.

CAPE CANAVERAL—At first glance Mercury-Redstone 4, nicknamed Liberty Bell 7, looks like the MR-3, Freedom 7 that carried Cmdr Shepard on US's first space flight. It weighs about 2 tons at lift off; measures 6 ft across its blunt bottom and stands 9 ft high. (*PE—May 1, p 15*). It carries the 16-ft escape tower and its major systems—environmental control, escape, communications, heat shield, landing—are similar. But design changes had been made to make this the latest spacecraft model.

Liberty Bell design changes were based on research, development, design, engineering, manufacturing, and flight test. They make the astronauts task a little easier, improve the design of the craft, and introduce new concepts that were untried at the time of construction of earlier models.

• **Window.** An enlarged "pilot observation window" replaces two 6 in. circular ports used in Freedom 7. The trapezoid-shaped opening measures 19 in. high, 11 in. across the base, 7½ in. at the top. It is located directly above the pilot.

Window will be used as a navigational aid to supplement the spacecraft's periscope and infrared-sensing equipment. It will give a direct view of the horizon, permitting the astronaut to determine the spacecraft's attitude. With reference lines inscribed on the four-pane window, the pilot should be able to hold the capsule precisely at the required 34° attitude for firing of retrograde rockets at the peak of the flight.

• **Pilot tasks.** The MR-4 pilot will have more time to look around inside and outside the capsule. Shepard carried out many more tasks than are usually attempted, for example, the use of manual control one axis at a time. Since Shepard met no difficulties in these maneuvers, the Liberty Bell pilot will flip a switch and pull a special "T" handle placing all three axes of the spacecraft attitude at his command.

• **Axes control.** After retrofire, the pilot will switch to another new system of manual control being flight-tested for the first time, Rate Stabilization and Control System, (RSCS). In the straight manual system used on the first flight, the hand controller served directly to open and close six jets at the base and neck of the spacecraft. These turned the craft on its axes. This type of control, while highly reliable, didn't offer very precise maneuver control.

In Liberty Bell, the manual as well as RSCS will be available. With RSCS, the pilot's hand motions are translated into electrical signals, which open or close solenoid valves controlling the jets. Precise control is expected.

• **Hatch.** Unlike the mechanically operated side hatch on Freedom 7, the MR-4 is equipped with a hatch secured by explosive bolts. The astronaut can jettison the hatch by pushing a plunger button inside the spacecraft or by pulling a wire. The explosive charge has been added as an additional pilot-safety device to insure easy and rapid escape in emergency. When jettisoned the hatch may travel up to 25 ft from the spacecraft.

• **Instrument panel.** Major design changes have been made in the MR-4 panel with instrument groupings functionally rearranged at the suggestion of the astronauts for quicker and easier reference. Notable among the changes is the addition of an annunciator (audio warning signal) panel.

• **Personal equipment.** The flight suit and bioinstrumentation are the same in design and function as equipment tested earlier with several minor exceptions:

Nylon-sealed ball bearing rings have been fitted at the glove connections of the suit, permitting 360° wrist action when the suit is inflated.

New voice microphone has been included as integral part of the pilot's plastic helmet. New microphone is expected to insure greater reliability and higher quality performance canceling out the inverter noise which reduced the quality of voice transmission.

Additional protective foam plastic will cushion the pilot's helmet in the contour flight couch to reduce noise and vibration during powered flight.

• **Other MR-4 changes include:** aerodynamic streamlining of the capsule-to-missile three-piece ring clamp fairing to reduce vibrations during transonic flight and at the point where maximum air loads are imposed; and a new launch angle resulting in a trajectory which will carry the craft one mile higher but three miles shorter downrange. ■

Fiber optics now inspect reactors

SAN FRANCISCO — Remote photographic inspection of the interior of a "hot" reactor–without dismantling –may be possible for the first time with fiber optics. Optics Technology Inc, Belmont, Calif, reports a probe will be delivered this summer.

It will be able to "see" cracks, corrosion, and other faults, says the company, that have been inaccessible to inspection and the probe may solve the vexing problems of reactor inspection and maintenance. The device consists of a ribbon-shaped probe 9-ft long, 3-in. wide, and less than 2 mm thick. One end of the probe moves along the surface to be inspected, simultaneously the other end moves along a strip of photographic film.

The probe is composed of five aligned layers of optical fibers, each 1500 strands wide (equivalent to 3 in.) and one strand thick, giving a total of 7500 fibers. Three layers transmit light from an outside source to the interior; the other two layers pick up the reflection from the inspected surface and transmit it back to the film. The result: a picture of the surface as it would appear to the eye, with resolution to 2 mils. Optics Technology says the device scans at about 200 in./min. ■

New compound promises wider ceramic applications

SAN DIEGO—A new material, said to promise widespread changes in the technology of sintering, bonding and fabricating ceramics, has been developed here by the Research & Development Div of Narmco Industries. Known as Pycerox, it is chemically processed at high temperatures in liquid form; crystallized, then mechanically reduced to powder for use with ceramics.

One of its most promising applications is in the liquid phase of ceramic sintering. When Pycerox is added to a melt, oven time and temperature required for sintering are substantially reduced. For example, 100% beryllium oxide takes about 60 minutes to sinter at temperatures above 3000 F. A mixture of 70 to 90% beryllium oxide, filled out with Pycerox, is said to sinter in about 5 minutes at 2000 F.

The material is also being used to bind ceramic flakes for making various-shaped components. The pieces that result reportedly have impact strength double that of their solid ceramic counterparts, though still about 1/10 that of a solid metal piece. Ductility is not appreciably improved.

The R & D group is also working on applications of the material to production of continuous ceramic fibers. Such fibers would represent an immense advance in the technology of building large shell-like bodies. These bodies are now machined from huge crystals—an expensive and difficult process, suitable almost exclusively for exotic applications. With continuous fibers, shell-like shaped could be filament-wound with relative ease and considerable savings.

Pycerox will bond metal to ceramic, metal to metal, and ceramic to ceramic. Company sources say that it has been successfully used to bond metal to ceramic in transistors, considerably reducing their size. With metals, the material may have applications in hermetic seals. And as a bond for ceramics, it opens the possibility of fabricating ceramic pieces, mosaic fashion, as an alternate way of building large shells.

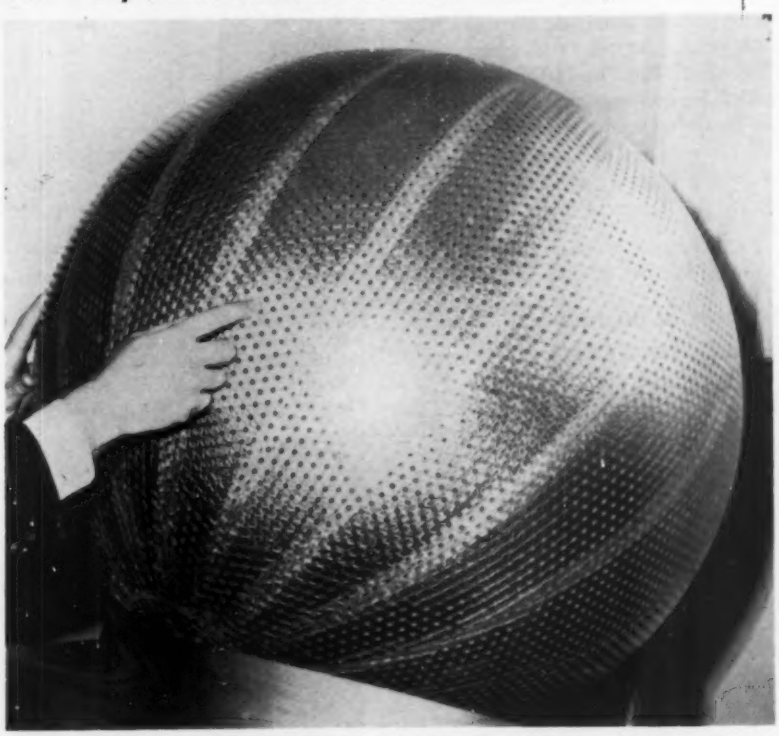
–Bill Wallace, Los Angeles Bureau

Electron-beam furnace on-the-line

KOKOMO, IND—New 300 kw electron-beam furnace at Haynes-Stellite Company, here, is making possible columbium, tantalum and a columbium-zirconium alloy with high ductility and good welding characteristics. These advantages come from the closer process control and higher purity of electron-beam melting as compared with vacuum-arc melting and powder metallurgy.

As produced by this new electron-beam melting equipment, columbium

Chemically milled satellite surfaces under study



Under evaluation for the National Aeronautics and Space Administration is this lightweight aluminum foil and plastic laminate balloon. The aluminum foil has chemically milled perforations in its shin, which are said to reduce weight of the inflated sphere by about 1/3, without effecting its rigidity. The material has been developed by Schjeldahl Co of Davenport, Iowa, for passive communications satellites such as Echo II *(PE—June 26, p 20)* or the proposed project Rebound in which several huge spheres will go into orbit with a single rocket launch. In such an effort, weight reduction will be especially crucial.

and columbium alloys with melting points over 3000 F and consistent mechanical properties offer new answers to high temperature problems. Tantalum alloys similarly produced provide exceptional corrosion resistance in a material that can be fabricated by usual methods.

Electron-beam melting in vacuum produces void-free, dense, high-temperature materials of higher purity and uniformity than obtained consistently by other melting processes. Melting is done in a vacuum of less than 0.01 microns. Furnace is capable of producing solid ingots 8 in. dia and 42 in. long, weighing over 500 lb.

Electron beam in the vacuum furnace is emitted from a tungsten wire loop, and directed against the end of the bar being melted. Melted metal drips into a water-cooled mold forming a round, dense ingot. Annealing, required in fabricating thin sheet, is accomplished in a vacuum of less than 0.1 microns at temperatures up to 2250 F.

With these facilities, Haynes-Stellite is now producing a new high-strength columbium base alloy Cb-752 containing tungsten and zirconium. The alloy can be fabricated and welded by conventional methods and has an ultimate strength of over 25,000 psi at a temperature of 2400 F. Welded joints are ductile. It is available in mill forms of sheet, plate and bar.

—R W Carson

Schools build new R & D facilities

WASHINGTON—The National Science Foundation has found that the nation's colleges and universities spent $154 million during 1958 for facilities and other capital items needed for R & D in the natural and social sciences.

These expenditures were distributed as follows: 50% for life sciences; 33% for physical; 15% for engineering; and 3% for social sciences. The heavy life sciences expenditures reflect medical school facilities.

About ¾ ($112 million) of the new facilities were financed by non-federal sources—the institution's own funds, State appropriations or private endowments. The remainder ($41 million) was contributed by the federal government. ■

High-temperature uses for boron silicide

MILWAUKEE—Graphite and molybdenum have excellent strength properties at high temperature but both oxidize unless atmosphere protected. Allis-Chalmers Mfg Co suggests an interesting solution.

Boron silicide is plasma-jet sprayed onto graphite which can then withstand an oxidizing atmosphere to 2500 F. Similarly protected, molybdenum will go to 1800 F. A-C reports it is working on a more impervious boron silicide to push oxidation resistance to even higher temperatures.

Protection, says the company, is provided by a thin layer of boron, silicon and oxygen that forms when the compound is exposed to a hot, oxidizing atmosphere. Once the layer is formed, further oxidation stops.

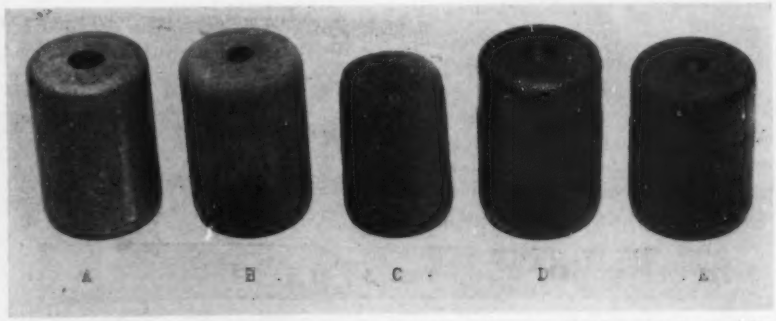
Coatings are about 0.004-in. thick, and the company claims three advantages over other metals and ceramic protecting coatings:

- Excellent adherence to base materials
- Coating does not crack in heating or cooling
- Boron silicides do not react chemically with graphite or molybdenum within temperature range tested—up to 2500 F.

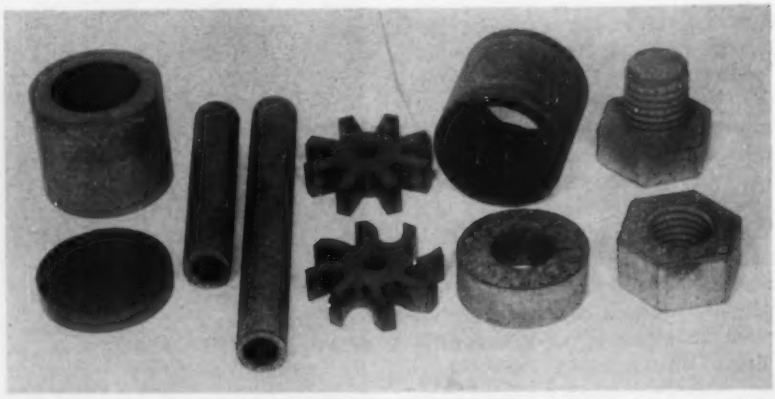
The boron silicide compounds tested so far are tetra-boron and hexa-boron. The adherence characteristics are partly caused by the nearly identical expansion coefficients of the materials: 6.3×10^{-6} for the coating, 5.5×10^{-6} for molybdenum, and 0.7 to 5.2×10^{-6} for graphite.

Both compounds are being manufactured in small quantities by A-C. The product is a fine powder (200 mesh) and can be sprayed or formed by several methods into various shapes.

—Bruce Cross, Chicago Bureau



OXIDATION TEST in stagnant air at 1800 F on boron silicide-coated graphite shows dimensional changes. Specimens were of the same diameter but not of the same height. (A) uncoated graphite and (B) coated graphite, both prior to heating. (C) uncoated sample after heating and (D) coated sample. Besides heating, sample was cycled betwen 1800 F and room temperature every hour for 6 hr. (E) Boron silicide coated graphite after continuous exposure to 1800 F for 6 hr.



SHAPES of boron silicide. Excellent thermal shock resistance is claimed for parts made of this material. Some shapes have been cycled repeatedly from 2000 F to 75 F without cracking, and parts can be water-quenched from 2000 F without cracking.

US firm licenses Soviet patents valued at $50 to $100 million

Moscow—An American firm has signed contracts with the Soviet government, which could open the way to major interchange of American and Soviet technology. Jerome Feldman, president of National Patent Development Corp, signed contracts with AMTORG—Soviet trading corporation headquartered in New York—under which the firm receives exclusive licenses to 50 to 70 Soviet patents.

National Patent, in turn, will sublicense patents to its customers—American Machine and Foundry, Avco Manufacturing Co, International Latex Corp and Thiokol Chemical. Signing of the contract followed negotiations with the Ministry of Foreign Trade and the State Committee for Coordination of Scientific Research—a group responsible for seeing that the latest Soviet technology is introduced into Russian industry.

Although company officials are reluctant to spell out details, items covered are known to include a microwire drawing method, transistors, thermo elements, diffusion welding process and fine wire encapsulation.

US firms, using this technology, will deal with NPDC. Feldman says his firm will make its profits from difference between what it pays the Soviets and what it receives from licensees. However, it is understood that the contract with AMTORG limits profit to an undisclosed percentage. Feldman estimates that if NPDC finds takers for half the Soviet patents he contracted for, the Soviet Union could earn $50- to $100 million yearly—far more than US-Soviet trade now.

When it came to Moscow, the American group had hoped to arrange a cross-licensing deal under which it would be middleman for technology moving in both directions. But so far, Feldman and his associates have found the Soviets more interested in licensing their technology than in taking licenses on American technology.

But the Soviets are interested in US patents. Arnold Cristen, a lawyer and member of the NPDC team in Moscow, says the USSR is the largest purchaser of patent copies from the US Patent Office. And American firms have found no way of protecting their rights in the Soviet Union. Feldman expresses the hope that if the Soviets begin getting revenue from their licenses, they will have incentive to honor world patent practices.

For the past two years, they have been filing for patents in Washington. But none has been issued yet because it takes three to four years to process an application. Elsewhere, the Soviets are licensing their technology in countries such as France, Sweden, England and West Germany.

—Ernest Conine, Moscow Bureau

IBM system conducts literature search in seconds

San Jose, Calif—In an effort to cope with the mounting store of technical information, IBM has developed an experimental electronics system, which can retrieve a page of text from millions stored on film in as little as 5 seconds of machine time. The system, known as WALNUT (no acronym intended), is now operating at the Advanced Systems Development Div here. As yet, IBM has no plans for commercializing it.

Documents entered into the machine are first microfilmed, then placed in an image converter, where the document size is again reduced and transferred to film strips. As the image is transferred to film, a control card is automatically punched to record location of the film in the document file. These control cards are retained in a subject index file.

Each document file contains 200 plastic cells, each of which holds 50 film strips. An individual film strip contains 99 images. Thus, a document file packs up to 990,000 images and the WALNUT system can accommodate up to 100 document files. (The average book has about 330 pages, IBM estimates; hence a document file can hold about 3000 books.)

To retrieve a publication from this massive file, a user simply writes on a form key words describing the material he wants—words such as "Smith," "computer," or "creativity." These key words are punched on paper tape and fed to the subject index file where a search of the control cards is made, at electronic speeds. A list of documents, appropriate to the key words, is then printed out.

The user checks the items on the list that he would like to see. Control cards for these items are pulled from the index file and certain data, such as the publication's location in the document file, are transferred to an aperture card having an insert of blank film. This aperture card is finally inserted into the document file, where it is exposed to the appropriate film strip by an optical system, using ultraviolet light. The film is developed within the machine by a dry heat process within about ½ second. After development, the card (containing up to four separate images) is returned to the user, who can then enlarge it for study. ■

Diamond powder cuts friction on sliding surfaces

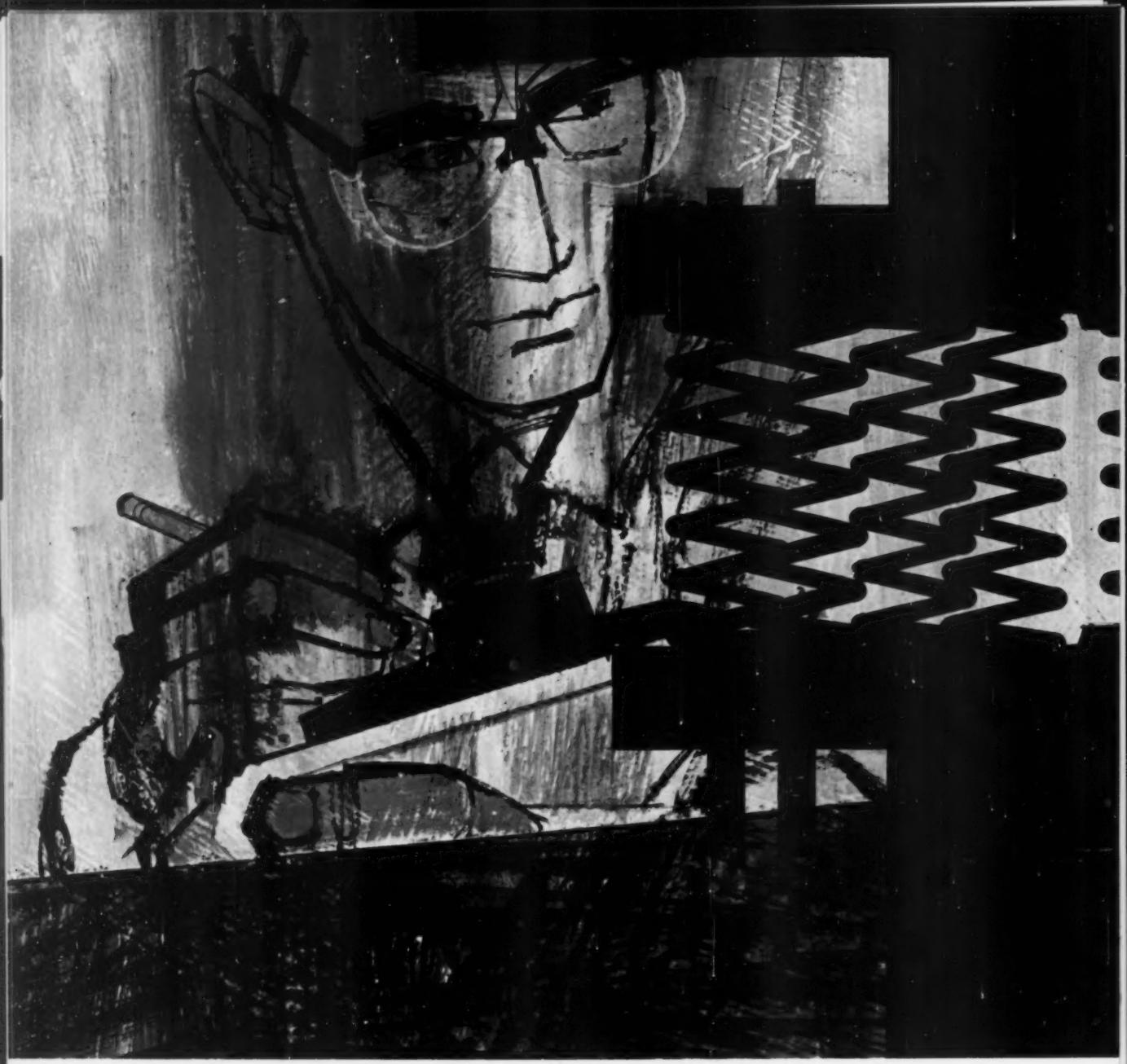
London—Small amounts of diamond powder, impregnated on sliding surfaces, can greatly improve load carrying capacity and diminish friction. This is the conclusion based on surface treatment experiments recently sponsored by Rolls-Royce Ltd, Derby.

In the endurance tests, Rolls slid an impregnated bronze surface against steel, that was lubricated with kerosene fuel. Loads on the test set-up were 300% of the failing load of conventionally lapped surfaces. Coefficient of stress was less than 0.001 micro-in. and tests showed excellent repeatability.

The experiments confirmed earlier experience reported by Joseph Lucas Ltd, makers of fuel pumps. The Lucas group fed fuel contaminated with silica of particle sizes 0 - 10 micro in. to a swash plate fuel pump. Instead of increasing wear rates, the contaminated fuel cut rate in half.

In the Rolls experiments, surfaces were prepared by rubbing them together with diamond powder at the interface. Particle size ranged up to 12 micro in. Other tests with silicon carbide were only slightly less favorable. ■

CIRCLE 20 ON READER SERVICE CARD→



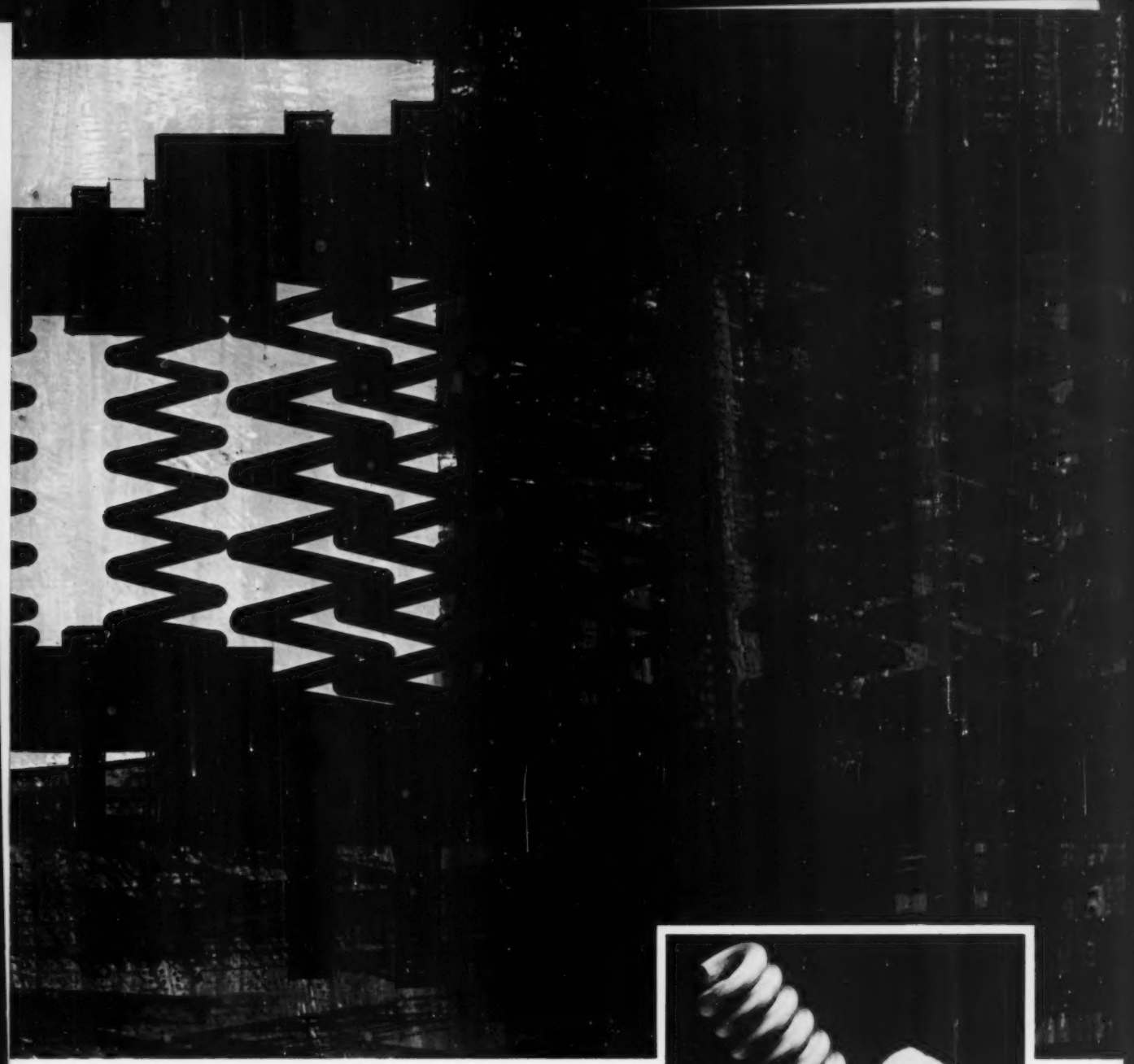
New N-S stainless wire tests 100,000 psi

From National-Standard research and development comes NS-355—a stainless steel, corrosion resistant spring wire having much greater elasticity than conventional stainless steel wire.

NS-355 is a semi-austenitic alloy, originally developed for use in heavy wire sections fabricated from bar, billet or plate stock—applications requiring corrosion resistance, strength, durability and hardness. National-Standard searched for a way to apply these outstanding advantages to highly stressed spring wire applications.

After comprehensive research in processing methods, National-Standard metallurgists developed the capability to draw NS-355 alloy into exceptionally high-tensile spring wire. Spring production tests were made on .125 and .075 inch diameter wire samples with a tensile strength over 100,000 psi higher than music spring wire, proving that NS-355 wire could be satisfactorily run on automatic coiling machines with excellent formability.

Further evaluation tests were conducted in the Spring Laboratory of Bendix Corporation, South Bend, Indiana. Here, engineers ran life cycle tests on NS-355 stainless steel springs and determined spring modulus values. On a mechanical cycling unit—eight springs to a fixture—NS-355 springs



above music wire

were subjected to 600 compression cycles per minute—a total of 10-million cycles under stresses from 20,000 to 150,000 pounds.

The development of NS-355 stainless steel spring wire creates an entirely new solution to highly stressed, corrosion resistant spring requirements for jet engines, food and beverage equipment, chemical machinery and a growing number of other special wire applications.

For more information about new NS-355 stainless steel spring wire, or help in developing high quality wire to meet your special or unique applications, write National-Standard Company, Niles, Mich.

National-Standard NS-355 stainless steel springs with an index as low as 3 can be formed on automatic coiling machines without breakage.

NS NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire & Metal Products

NATIONAL-STANDARD COMPANY

Niles, Michigan

61-W03

Replace costly machined or molded parts with formed RULON® Tape.

Leading manufacturers across the country are cutting design costs by stamping or post-forming parts from RULON (filled TFE) tape. With Dixon's RULON Tape in thicknesses from .004" to .125", you pay only for what you *use*. You use a *minimum* of material . . . and reduce costs up to 10 to 1. You take advantage of RULON'S plastic memory, too, for tighter fits and better seals. RULON Tape gives your product these performance-improving qualities: (1) low friction, (2) high wear resistance, (3) low deformation under load, (4) wide temp. tolerance (−400°F to +500°F), (5) chemical inertness, (6) lube-free operation, and (7) zero water absorption.

Dixon offers RULON and TEFLON in
- rods
- tubing
- sleeving
- sheet
- tape
- extruded shapes
- bearings
- bushings
- washers
- gaskets and packings
- bearing retainers
- machined and molded parts

Whether you need stamped or post-formed parts for pumps, valves, compressors, bearings, meters, or what have you, it pays to rely on (1) Dixon's wide selection of basic shapes (in both RULON and Teflon), (2) Dixon's knowledge of fluorocarbon reinforcing agents, and (3) Dixon's facilities for fabricating parts to print.

See RULON designers guide book — Bulletin #9572 in Sweet's Product Design File, or send details for recommendations. DIXON CORPORATION, 103 BURNSIDE ST., BRISTOL, RHODE ISLAND.

* DuPont T.M.

DIXON

READER TO EDITOR

Increased emphasis on education—where?

To the Editor:

The editorial "You and Tomorrow" June 12, p 55, was a true thought stimulator. You mentioned the increased emphasis that is placed upon education, the sense of security that increased education has instilled in some quarters. And you wisely questioned, "Does this trend produce better research, better science, better engineering?"

Upon reading through the other pages of that particular issue I think some trends toward an answer to your question are in evidence. In the "From Washington" page there is the comment about the Apollo contract, "It goes beyond sheer technical ability and plant and managerial capacities. The added ingredient of politics is being rated high in the maneuver." Is this the result of the advanced education of our age? Elsewhere in the issue is a quote from a Mr. Will Scott of the Ford Motor Company, "Good engineering or good styling is engineering or styling that can be sold at a profit." Has modern education led us to the level where profit is the determining factor in what is or is not good engineering or good styling? My understanding has been that selling something at a profit is good salesmanship.

—A R JESSEN
Englewood, Colorado

Stirling engines

To the Editor:

In your June 26 issue, p 3, you state that the German firm Otto and Langen made and sold 35,000 successful Stirling engines. I am very interested in this and would be grateful to learn when this firm produced these machines, how they were designed, and any other relevant information you may have. Incidentally, to correct a minor error, the Batteile solar engine which is illustrated in your cover picture and mentioned in the text operates at a speed of 1500 rpm, not at 100 rpm as stated.

—T. FINKELSTEIN
Associate Staff Engineer
Battelle Memorial Institute
Columbus, Ohio

• Otto and Langen sold 35,000 Otto engines—IC engines, not Stirling—which for their days was quite a feat.—Ed.

Man's decision, not the corporation

To the Editor:

Congratulations on your editorial of July 3, "War on War," p 23. I think that there is a wide-spread assumption held by those engaged in the business of weapons that because a large corporation or government agency is engaged in the weapons hardware business, the business itself must have some kind of moral validity.

This is a myth, which arises from the separation of the individual and the corporation image. The truth of the matter is

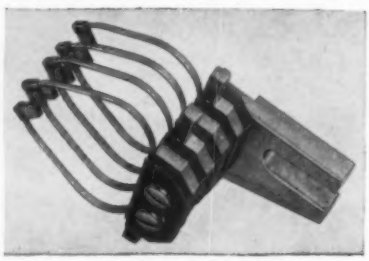
continued, page 23

CONTACTS
◆
Brush Holders
◆
Standard and Special for all makes of slip ring assemblies

by SCP

Contact grades offered by Superior are most varied and fulfill many combinations of requirements. Superior pioneered in the research, development, and manufacture of silver contact grades, setting standards now universally recognized by industry.

Contacts are ready for attachment to arms or springs. We offer full facilities for attaching contacts to arms or springs and can frequently effect worthwhile savings.



Important to contact and slip ring operation is the brush holder assembly. Together with the selection of proper materials, Superior-assembled contacts and holders provide the vital link in the efficient operation and long life of slip ring assemblies. Superior is thoroughly versed in the requirements of high altitude, noise level, and similar conditions.

Call upon Superior Carbon for assistance with contact problems. You benefit from long experience in this area.

SUPERIOR
TRADE SCP MARK
CARBON PRODUCTS, INC.
9115 George Avenue · Cleveland 5, Ohio

that the individual *is* the corporation, whether he be employe or stockholder. This separation, which exists in the mind of the individual, exists in proportion to the vastness of the awesome organization. (How can one identify with a letterhead or a million-dollar contract?)

Moral decisions, are not made by corporations, they are made by individuals. The individual who attempts to let the corporation carry the weight of his moral responsibility is not being realistic. The most important moral decision that a contemporary engineer or scientist can make lies in his choice of the objects which he develops or builds.

It is not an agency which decides to construct nuclear war heads, but the individual who chooses to work for that agency.

I do not know what man's ultimate commitment is or should be, but I am convinced that the direction toward this commitment should be constructive and not destructive.

I, for one, do not wish to contribute to genocide, whether in the name of national defense, or in the name of murder.

—William H Sturgeon, Jr.
Berkeley, Calif

COMING EVENTS

AUGUST

22-25 . . . . Institute of Radio Engineers, WESCON Electronic Show & Convention, The Cow Palace, San Francisco

23-25 . . . . American Institute of Electrical Engineers, Pacific General Meeting, Salt Lake City, Utah

28-Sept 1 . . . . American Society of Mechanical Engineers and American Institute of Chemical Engineers; Institute of Mechanical Engineers and Institution of Chemical Engineers (Great Britain), International Heat Transfer Conference, Univ of Colorado, Boulder

SEPTEMBER

11-14 . . . . Society of Automotive Engineers, National Farm Construction & Industrial Machinery Meeting, Milwaukee Auditorium, Milwaukee, Wisc

14-15 . . . . American Society of Mechanical Engineers, AIEE and IRE, Joint Societies Engineering Management Conference, Hotel Roosevelt, NYC

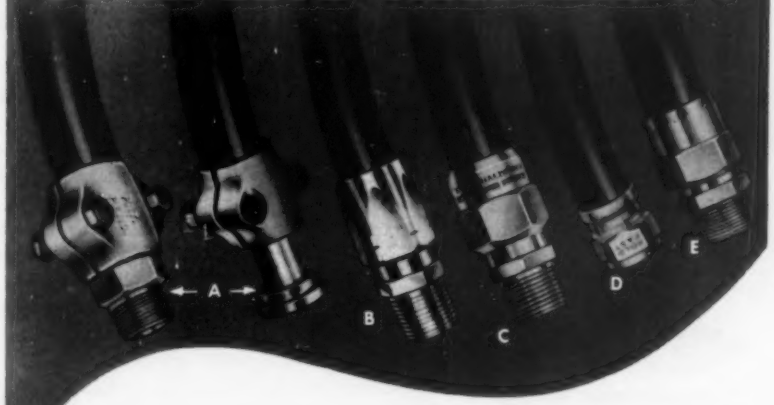
20-21 . . . . Institute of Radio Engineers, AIEE and ISA, Industrial Electronics Symposium, Bradford Hotel, Boston

25-28 . . . . American Welding Society, Fall Meeting, Adolphus Hotel, Dallas, Texas

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.

The Anchor Emblem..... on REUSABLE COUPLINGS *signifies* COMPLETE RELIABILITY

ANCHOR
THE PLEDGE OF PERFORMANCE



THESE ARE THE ANCHOR REUSABLE COUPLINGS

For High Pressures

A. Anchor Threaded and "O" Ring Flanged Head Clamp-Type Couplings.

B. Anchor Two Piece Cover Strip Reusable Couplings for Wire Braid Hose.

For Medium and Low Pressures

C. Anchor Duloc Couplings for Styles QW and QWR Hose.

D. Anchor Hold-Fast Reusable Couplings.

E. Anchor Two Piece Reusable Couplings for Rayon Braid Hose.

You get *complete reliability* . . . day after day . . . when the Anchor emblem is stamped on these easily applied, streamlined Anchor Reusable Couplings. Anchor's "Pledge of Performance" signifies sure, leakproof connections.

Design-engineered and manufactured to rigid, precision standards for *quality*, *dependability*, and *performance* . . . whether used on original equipment or for replacement . . . Anchor Reusable Couplings are "standard" for hydraulic transmission lines where fast, emergency repair and field service are essential.

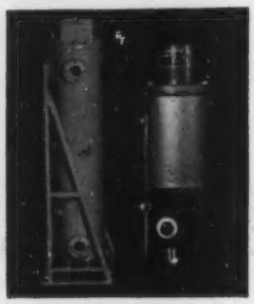
Send for the Anchor Catalog No. 304 which gives detailed specifications of the different types of Anchor Reusable Couplings available. There's one or more for your particular hydraulic equipment use.

Andy Anchor says: "Your nearest Anchor field engineer can show you how easy and simple it is to use Anchor Reusable Couplings on your equipment . . . in the field . . . on the road . . . and in the shop.

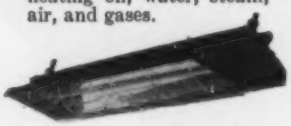
ANCHOR Coupling Co. Inc.

330 North Fourth St., Libertyville, Ill.
Branch Plants: Dallas, Tex., Plymouth, Mich.

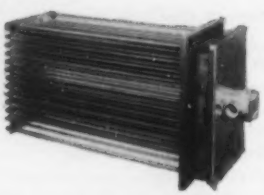
VULCAN
for complete electric heat



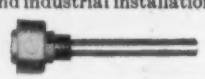
VULCAN CIRCULATION HEATERS
Complete range of sizes for heating oil, water, steam, air, and gases.



VULCAN RADIANT HEATERS
Unlimited applications for spot comfort heating and drying.



VULCAN AIR DUCT HEATERS
For residential, commercial, and industrial installations.



VULCAN IMMERSION HEATERS
For direct immersion in all types of liquid materials.

Whether you need complete units or component elements, rely on Vulcan Versatility in product, engineering, and service. *Write for catalog.*

VULCAN
Versatility in Electric Heating
VULCAN ELECTRIC COMPANY, Danvers, Mass.

FOR YOUR INFORMATION (personal)

How deep is the fish?

THERMO-FISHOMETER is housed in 6 by 3½ in. phenolic case. Sensing probe, reel and 100 ft of depth-marked wire, shown disassembled here, normally fit in case. Inserting jack in receptacle completes circuit and makes the unit ready for use.

Is your future catch swimming in the epilimnion, or lazily basking in the hypolimnion? You'll have to know to get the hook in the right place, says Bright Radio Labs, and it has the electronics to do it.

Bright also has an explanation for those Greek words. The epilimnion is the top (warmest) layer of water; the hypolimnion, the bottom or coldest. In between is a third layer, the thermocline. Each fish, says Bright, has a preferred level and generally sticks to it. All you need to know, then, is which level your fish likes, and the Thermo-Fishometer does the rest. It probes the depths, converts temperature to level, and provides a meter reading. It's battery-operated, comes complete with canvas case and a chart showing preferred temperatures of major game fish. (Bass like it hot: 70 to 75 F; lake trout like it cool: 40 to 50 F.) The price: $29.95.

Intercoms on skis

While sailing along on your water skis this summer, you won't have to feel scared or lonely. Tithe Mfg Co has come up with an intercom system, with connections built into the tow rope, that will sound an alarm in the boat the minute you take a header. It has a 2-way beeper system, too, operated by a pressure-release switch on the tow-bar handle and a push-button on the boat's instrument panel, that will let you send simple, Morse code-like signals for stop, start, and turns. The whole business is waterproof, Tithe says, and will operate from the boat's 12-v starting battery. Retail price is about $40 for the tow rope and bar, control panel, relay, and signal units.

Batting out the story

HANDY INSTRUCTOR is wireless, transistorized radio. It guides youngsters through science exhibits at London's Science Museums.

The British have a new design in portable paging—and an interesting way to put it to work.

Basically, the system is just like those used in US factories and hospitals. But the receiver is housed in a novel earphone-handle, and it's used to guide youngsters through science exhibits. The unit is transistorized and battery-operated. Overall length is 20 in; weight, 7 oz. The tape-recorded commentary is transmitted through a loop antenna running around each museum gallery. The full talk lasts 20 min. Multitone Electric (US Representative: Multitone Electronics Ltd, Buffalo) designed the system. —ARG

PRODUCT ENGINEERING **HORIZONS**

July 31, 1961

Not how much, but how well

Rapid reading never got a greater boost than it did with the change of administration. All the ambitious Washingtonians are taking courses or bragging; perhaps are even reading a book or two.

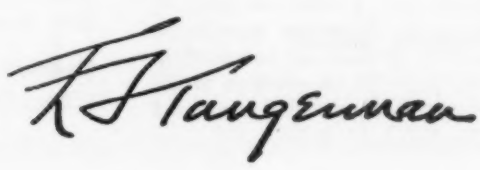
A McGill professor, Paul Nash, recently pointed out that reading may be: (1) for information, (2) to stimulate thought, (3) to help our personal development; (4) for enjoyment; (5) "for the purpose of avoiding thinking."

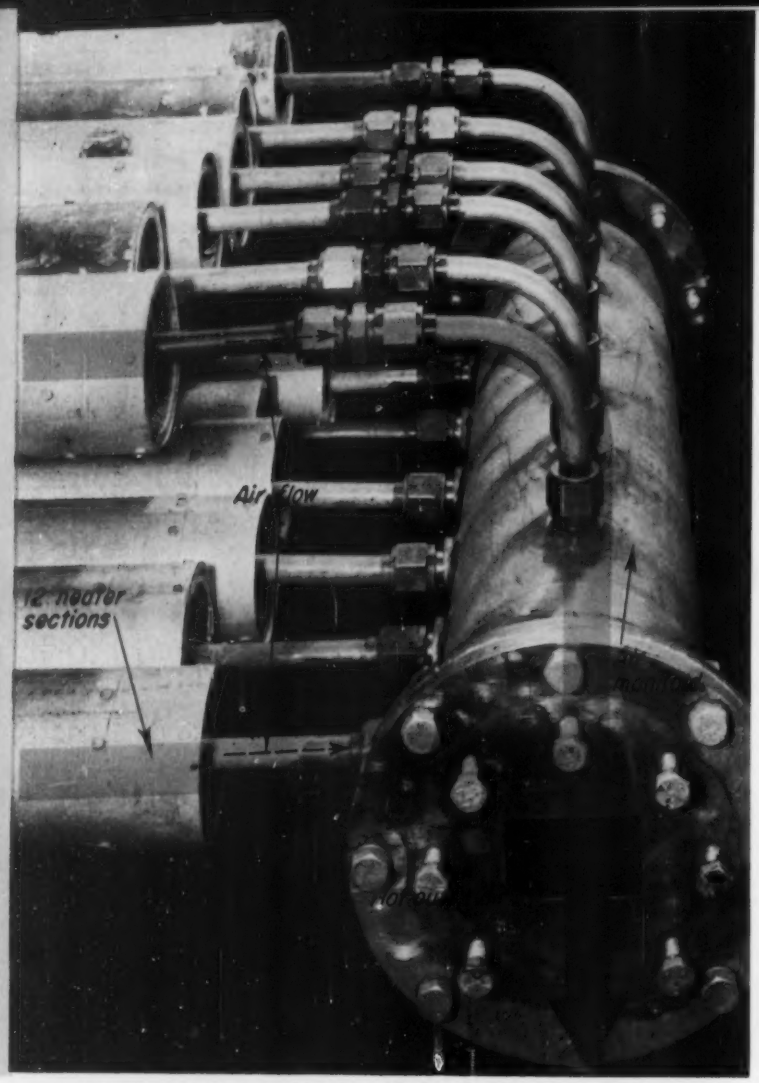
Maybe we should add (6) to keep up with the Kennedys. Class 6 may include the idea of reading the books and articles that everybody else is talking about. In any case, Professor Nash goes on to advise that we read less (particularly of Type 5 "literature") and that we be *selective* rather than comprehensive. He sees no advantage in "inert knowledge," suggests that reading be selected for yourself, to suit your makeup, experience, and interests—nobody else's. Read only what arouses a genuine interest in your mind.

Nash makes two suggestions that the engineer is particularly well equipped to employ. One is that we read only the *best*. This means to cut down on newspapers and magazines which are "mostly written for titillation of emotions," to cut down on bulletin and report detail that adds no information, to avoid the reading matter that previous experience says pays back very little for the time spent in reading it. Too often, the engineer who cries that "there's too much to read" is admitting his own failure to be selective. As some wag once said, "You don't have to try *all* the eggs in the dozen to find out that they're bad."

The other suggestion is that we learn to read with deliberate skill and control. Reading speed should *not* be uniformly fast; it should be varied to suit the flavor or the value of what's being read. You needn't read every word of every piece; skimming is enough for much writing because it's verbose. Read in detail only when close reading repays your time investment. This takes conscious effort and training, but it repays in a higher concentration of ideas.

It isn't how *much* you read that's important, it's what you *select* to read and how *well* you read it. If you can discriminate, reading can be both profitable and a pleasure.





A DOZEN TERMINAL RESISTANCE HEATERS are manifolded to heat 300 standard cfm of air to 1600 F. Heater sections shown are 0.5-in.-dia stainless-steel tubing, 0.065-in. wall, covered with high-temp insulation. Electrical terminals (not shown) are clamped to tubing.

HOW TO HEAT AIR FOR TESTING

Heat-test your product at any temperature from ambient to 500,000 F with air as the medium and the right heating method. Here are handy selection tables, plus details on the most versatile method—terminal-resistance heating.

W K MOEN,
Lead engineer
Space and Information Systems Lab
North American Aviation, Inc

■ Air and other gases are the only heat-transfer media that withstand the abuse of extreme temperatures (both low and high) and are easily piped into the test chamber. But how do you heat the air quickly and economically in the first place?

Thanks to lab developments, you may now choose among 6 proven air-heating techniques (with a half-dozen variations) to help you meet requirements of temperature range, airflow rate, test-chamber size, temperature control, and over-all cost.

The most recent developments have been in terminal resistance heating—simply a modern application of the electric resistance element. Heat output depends on I^2R, where I is electrical current and R is resistance of the heater, but new materials and concepts have made resistance heaters more versatile.

Other air-heating methods also in advanced states of development are: chemical, fuel combustion, regenerative storage, and electrical arc. All methods are compared in the performance table on page 28. A previous article covers an alternative heating technique that doesn't need air: Infrared radiation (*PE*—Feb 1 '60, p 39).

THE SIX WAYS

Chemical heating

Chemical-reaction heaters produce the highest flame temperatures—some reaching 8400 F—but their relatively cumbersome heat exchangers limit outlet air temperatures to 1000 F. "Thermit" is a chemical mixture of finely divided aluminum and iron oxide powders with a reaction temperature of 4000 to 4500 F, once ignited. No electricity is needed, and there is no gaseous byproduct, but the reaction is difficult to control.

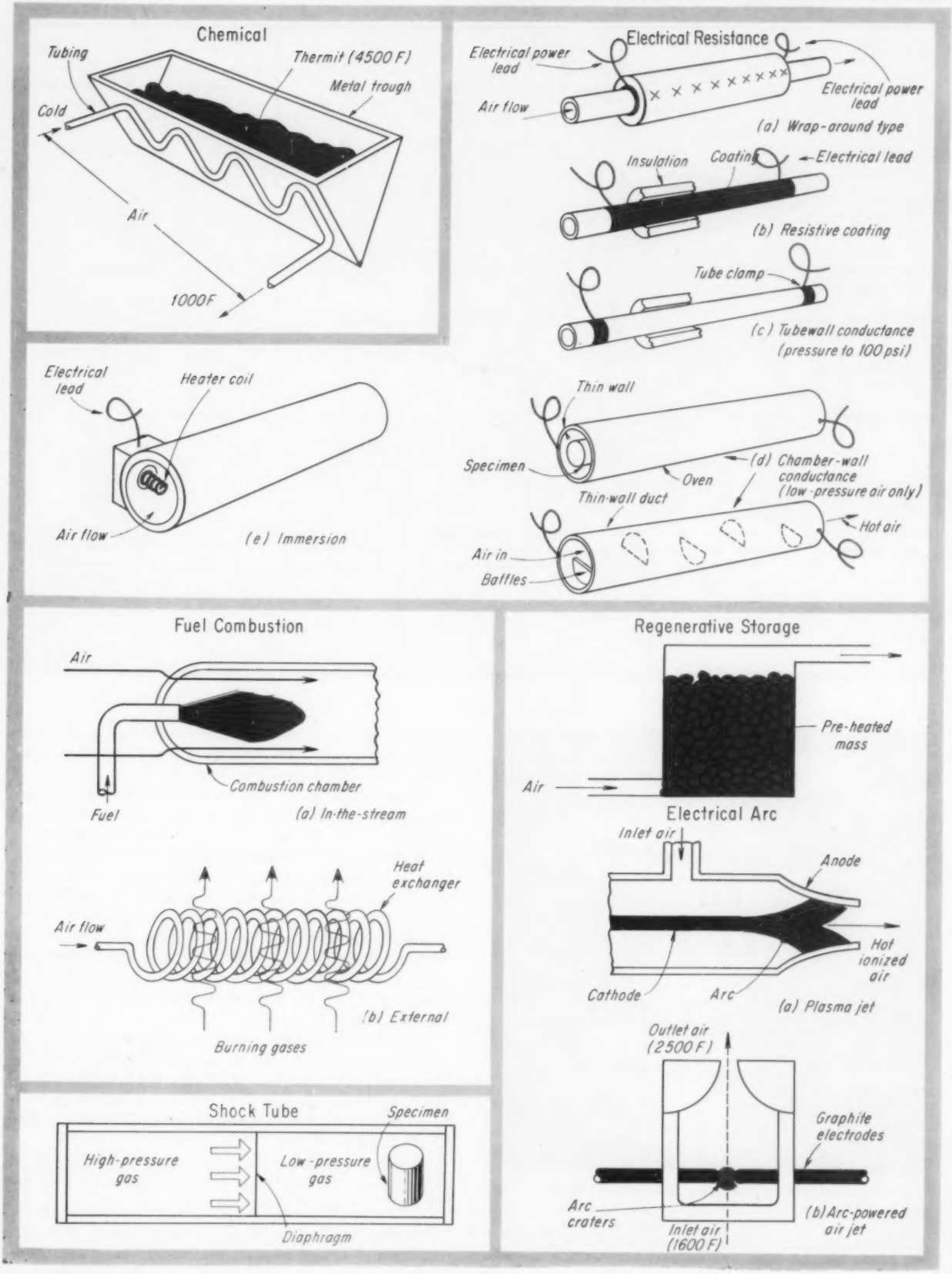
The Thermit mixture is confined in an insulated copper trough with coils of copper tubing attached to the underside. Cool air passes through the tubing and is heated to 1000 F; followup electrical heater which allows better control brings the air to higher temperatures—to 3000 F. Cool air may be added at the tubing outlet with a mixing valve to improve temperature control.

Electrical resistance

Electricity is readily available and easily controlled with

text continued on page 28

REPRINTED—Circle 620, inside back cover


Chemical
Tubing
Thermit (4500 F)
Metal trough
Cold
Air
1000F
Electrical Resistance
Electrical power lead
Air flow
Electrical power lead
(a) Wrap-around type
Insulation
Coating
Electrical lead
(b) Resistive coating
Tube clamp
(c) Tubewall conductance (pressure to 100 psi)
Electrical lead
Heater coil
Air flow
(e) Immersion
Thin wall
Specimen
Oven
(d) Chamber-wall conductance (low-pressure air only)
Thin-wall duct
Hot air
Air in
Baffles
Fuel Combustion
Air
Combustion chamber
Fuel
(a) In-the-stream
Heat exchanger
Air flow
(b) External
Burning gases
Regenerative Storage
Pre-heated mass
Air
Electrical Arc
Inlet air
Anode
Hot ionized air
Cathode
Arc
(a) Plasma jet
Outlet air (2500 F)
Graphite electrodes
Arc craters
Inlet air (1600 F)
(b) Arc-powered air jet
Shock Tube
Specimen
High-pressure gas
Low-pressure gas
Diaphragm

Comparison of high-temperature air-heaters (all values approx.)

	Chemical	Electrical resistance	Fuel combustion		Regenerative storage	Electrical
			in the stream	external		arc-powered jet
Max outlet air temp, °F	1000	2000	4500	1000	4000	3000–5000
Flow range, cfm (std) max	500	500	500	1000	1000	500
Flow range, cfm (std) min	30	2	30	50	200	20
Size of largest test specimen	6 cu in.	6 cu ft at 400 F; 2 cu in. at 2000 F	3 cu in.	6 cu ft	3 cu ft	3 cu in.
Ease of temp control	poor	excellent	good	good	fair	good
Suitable heat-transfer media besides air	gas	liquid; gas	oxygen; gas mixtures	liquid; gas	gas	oxygen; gas mixtures
Heat exchanger	copper and steel with tube and plate	none; or tube, plate	none; or liquid	tube; plate	zirconia pebbles	none
Combustion byproducts	non-gaseous for thermit	none	burned hydrocarbons			consumable graphite
Advantages and limitations	inconvenient and inflexible, but handles large air volumes	versatile; long life; continuous flow; convenient	compact; high-pressure operation; long life	large air volume; continuous flow; not very flexible	high stagnation temperature; but contaminates stream	high radiant and convective heat; poor stability; 10 minute limit

TERMINAL-RESISTANCE HEATER in drum form has coiled tubing surrounded with high-temperature insulation. Electrical terminal is clamped to each end of the tubing. 10-kw version shown can heat oil, gas or water. (Test data on next page.)

a resistance heater—two important advantages. For temperatures up to 2000 F, there are few methods as versatile. Take your pick of these five variations:

Wrap-around surface heaters are wired blankets, woven-impregnated cloth, foil, or resistive film elements. A previous article (*PE—Feb 2 '60, p 33*) gives details.

Resistive-coating surface heater is a variation of the wrap-around heater; the coating is applied to the outside of the air pipe or heating chamber. It is useful in special cases where wrap-around elements won't fit easily.

Tubing conductance has the tubing itself as the resistance element and electric terminals are clamped on each end. The tubing can be stainless steel (for shop-air pressure) or graphite (for low pressures). Air can be heated to 2000 or 3000 F.

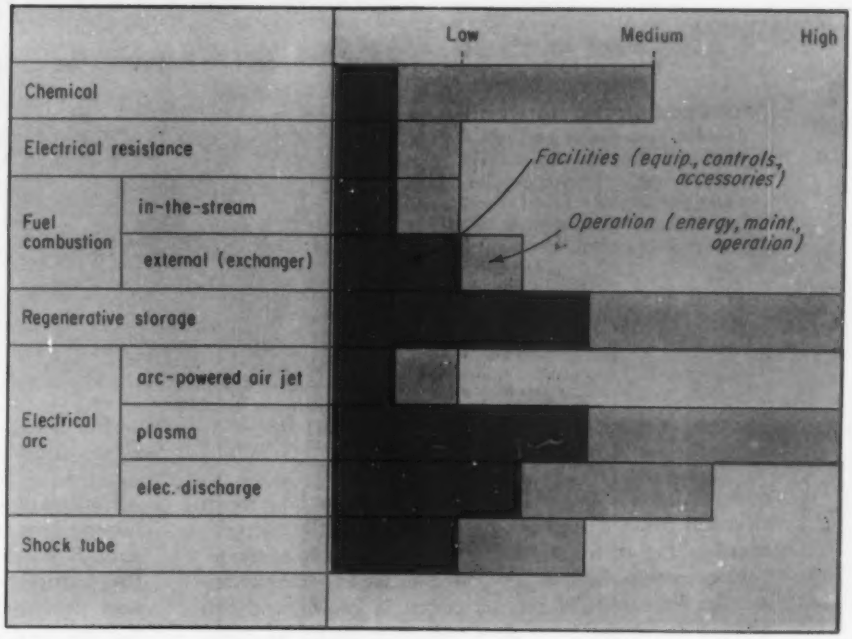
Chamber-wall conductance has a thin-walled (0.006 in. or less) cylinder of metal as the heating chamber—it can be a galvanized stovepipe. The thin wall conducts current from end to end, heating in proportion to I^2R. Air pressure must be low (about 3 or 4 psi) and internal baffles can help direct the flow.

Immersion heater is simply a coil or rod of special resistance material. Air is heated when it passes over the hot element.

Of the five variations, only two—wrap-around surface heaters and tubing conductance heaters—meet all the re-

arc		Shock tube
plasma jet	electrical discharge	
30,000	20,000–500,000	30,000–40,000
—	—	—
—	—	—
3 cu in.	—	—
fair	poor	poor
hydrogen; nitrogen; argon	gas	gas
none	none	none
none	none	none
versatile in small jets; no low temperature or low velocity; 60 minute limit	requires high current density (100–400 amp per sq cm); short pulses of heat (microsec)	short time heating (for one pulse only)

Relative over-all cost of air-heating systems



quirements for high-temperature testing. Details are given later in the section on terminal resistance techniques.

Fuel combustion

Really a variation of chemical heating, fuel combustion is important enough to be classified separately. Limiting temperature is about 5000 F for direct combustion in the airstream (expansion-type combustion chamber using air or oxygen to support combustion). If a heat exchanger (tube or plate) is used, temperatures will be lower. (Inlet gas temperature to a heat exchanger is normally limited to 1000 F, but can go higher when special exchanger materials are used.)

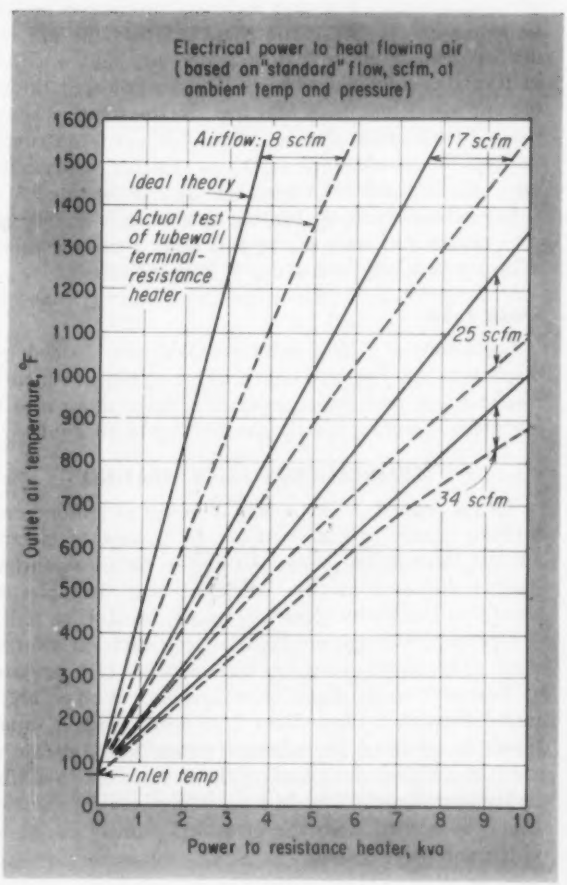
Almost any fuel will work. Butane gas is one of the simplest to handle and its byproducts are fairly clean.

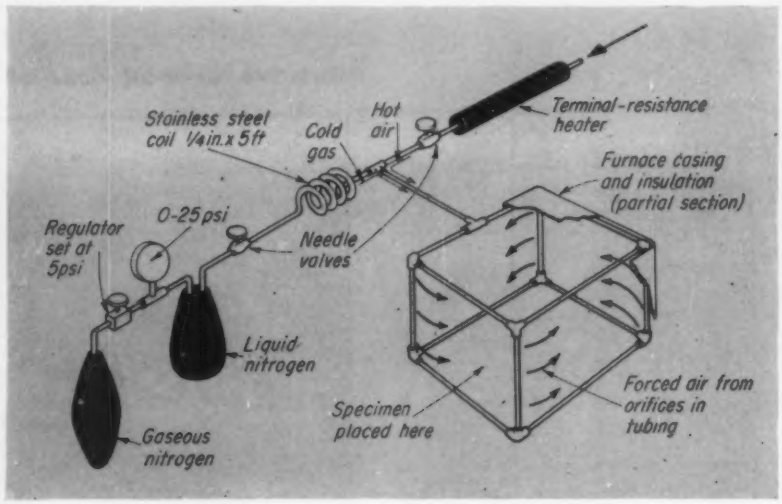
Regenerative storage

Tons of pebbles, stainless-steel balls, and other thermal masses are heated beforehand by a suitable regenerative system. Then air is heated continuously to above 4000 F for a limited time by forcing it through or over the heated mass. Outlet air temperature will begin to drop when half the stored heat is gone.

Electrical arc

Arcing in a gas raises its temperature momentarily as high as 500,000 F (for microsecond periods) or continu-





FORCED-CONVECTION FURNACE doubles as a cooler and can also be used for thermal-shock tests. Hot air and cold nitrogen can be mixed in any proportion to control temperature in furnace from —65 to 1200 F, and will go rapidly from hot to cold, or cold to hot.

ously (1 hr) to 30,000 F. It all depends on how much electrical power is available, and how quickly the energy is added to the airstream. Two methods are fairly common.

Consumable-electrode arc-heated air jet has graphite terminals. Emissivity of the arc craters is known, and this gives a radiant-heating effect which is useful in some applications. Typical outlet air temperature is from 3000 to 5000 F.

Plasma jet has non-consumable electrodes in a carefully designed nozzle. They carry high arc current and heat the air to 30,000 F. Jet-nozzle shape restricts the arc to a smaller diameter than that of a free arc, thus increasing its resistance and temperature. The air is forced through the arc where it ionizes into free electrons and positively charged ions—called plasma. Method is useful in materials testing, thermo-chemical reactions, particle vaporization, metal cutting and other high-heat-flux applications.

In electrical-discharge heating an extremely high-current arc (hundreds of amps per sq cm) heats a trapped volume of air up to a half-million deg F in microseconds.

Shock tube

Shock-tube is a long metal gas-filled tube divided by a diaphragm into low- and high-pressure sections. When the diaphragm is ruptured, compression waves move into the low-pressure section and the gas heats up to 40,000 F.

TERMINAL-RESISTANCE HEATING

This is defined as the heating of bodies of uniform cross-section, usually in the open air, by passage of electrical current through the body. All of the electrical-resistance heaters discussed in this article fit that definition—the "body" is the heater element (tubing, blanket, or coil).

Operating voltages are kept low for safety in most test work. The North American system (0 to 24 v ac) works as follows: a single-phase 440-v ac source is smoothly adjusted through a range from 0 to 440 v with a variable power transformer; the adjusted voltage is fed to the primary of a high-current heating transformer that has a normal output range of 0 to 24 v ac. The secondary (heating) circuit is isolated from the grounded primary circuit—an important safety feature.

Control of a TRH (terminal-resistance heater) is simple because heat input is proportional to I^2R, where I is current, R is resistance. Efficiency is good—95 to 97% of the electrical energy is converted by the element into useful heat. Response to a change in input is rapid because the thermal mass of the heater is small compared with the flowing mass of air being heated.

Cost is low for an initial installation, although operating costs are higher than for combustion heaters burning cheap fuel. Initial cost of a tubewall-conductance TRH can be as low as $15, including the commercially available stainless-steel tubing, terminal clamps, and insulation.

Performance of a typical TRH tube heater is plotted on the previous page. Data are converted to scfm (standard cfm) and compared with theoretical performance of a 100% efficient (no heat loss) heater.

Cold air is occasionally needed in product testing. A unique advantage of TRHs is that the hot outlet air can be conveniently mixed with cold air from another source, and the mixing temperature accurately controlled at any value from —65 to 1200 F. The combination forced convection furnace and supply system sketched above is one way to "mix" flows, and with it you can shock-test a specimen by switching from hot to cold and back.

For REPRINT of above article, just check 620 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: Heat, its control, and temperature measurement have been covered in this recent series of PE articles:

Surface-type Heaters, Jan 30 '60, p 42—Describes all types of area-source heaters, including blanket and resistive-coating, and shows how to choose the right one.

Keeping the Component Warm, March 13 '61, p 61—Article has shortcut method for estimating the heat to bring a specimen or product up to temperature and keep it there. Temperature range is from —200 to 400 F.

Infrared for Heating a Product, Feb 1 '60, p 39—Compares performance of radiant, induction, dielectric, resistance and other heating methods. Has general discussion of radiant-heat theory with simplified charts for estimating emissivity of surface coatings.

Temperature-measuring Transducers, May 22, '61, p 49—This is a special report on the latest devices to measure temperatures from almost absolute zero to over 1,000,000 F.

—F D Yeaple

What you can do with NONSTANDARD SPUR GEARS

Altering pressure angles offers increased freedom in selecting center distances, gear ratios and speeds, and no special manufacturing tools are required.

EDWARD A BRASS,
Chief, preliminary mechanical design
Lycoming Div, AVCO Corp, Stratford, Conn

■ Often precise gear-ratio specifications make it difficult, or even impossible, to produce a workable planetary gear combination with standard spur gears. This is particularly true where space limitations must also be considered. Special center distances or gear ratios of ordinary gear combinations are equally impossible with standard spur gears.

Nonstandard spur gears can overcome such limitations and offer other advantages as well. Low operating pressure angles offer better backlash control, less noise, less shock, and higher contact ratios. High operating pressure angles provide increased load-carrying capacity.

Pressure-angle variation is the key

Standard spur gears operate with either a 14½, or a 20 deg pressure angle. But two gears manufactured for standard operating pressure angle and center distance can be operated at nonstandard pressure angle with corresponding center distance, providing proper tooth engagement and backlash are maintained. In a planetary gear system (see diagram) the mathematical relationship between pressure angle, center distance, diametral pitch, and number of gear teeth is:

$$C = \frac{N_s + N_p}{2P} \frac{\cos \phi}{\cos \phi_e} \qquad (1)$$

SYMBOLS

C — Center distance, in.
N — Number of gear teeth
P — Diametral pitch
R — Overall gear ratio
ϕ — Manufactured pressure angle corresponding to manufactured diametral pitch.
ϕ_e — Operating pressure angle of the external mesh.
ϕ_i — Operating pressure angle of the internal mesh.
ϕ_1 — Operating pressure angle of primary mesh in double planetary.
ϕ_2 — Operating pressure angle of secondary mesh in double planetary.

Subscripts

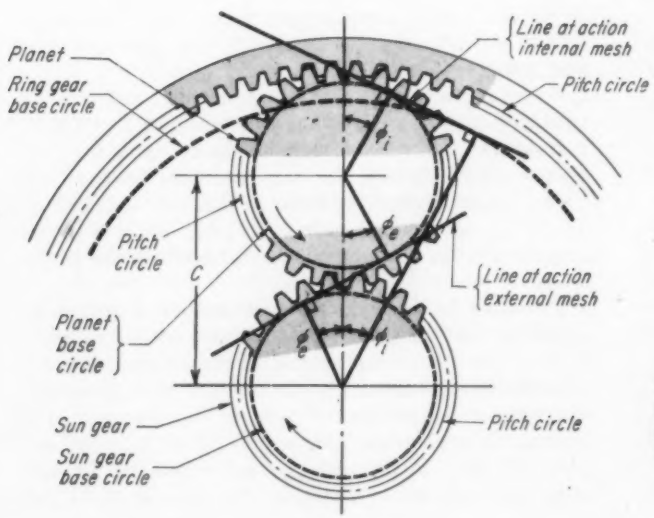
p — Planet gear
r — Ring gear
s — Sun gear

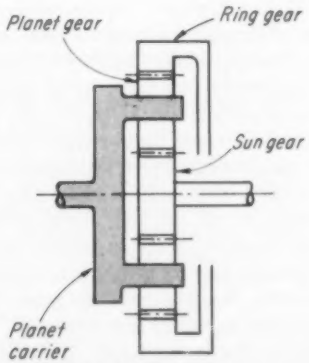
$$C = \frac{N_r - N_s}{2P} \frac{\cos \phi}{\cos \phi_i} \qquad (2)$$

For a simple gear and pinion combination the center distance is the same as in Eq (1), which with Eq (2), establishes the center distance for planetary gears.

When standard spur gears are used, the pressure angle is the same for both meshing gears. This makes the right-

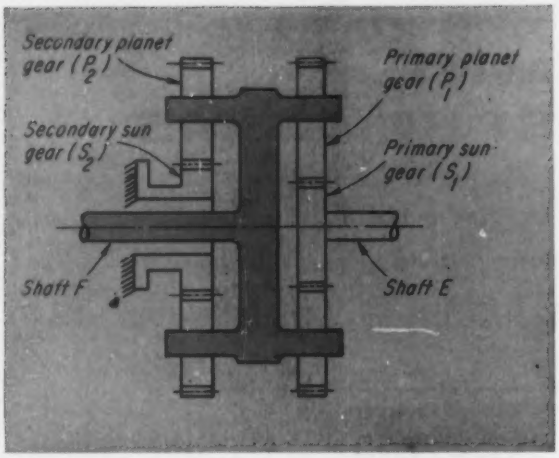
continued, next page



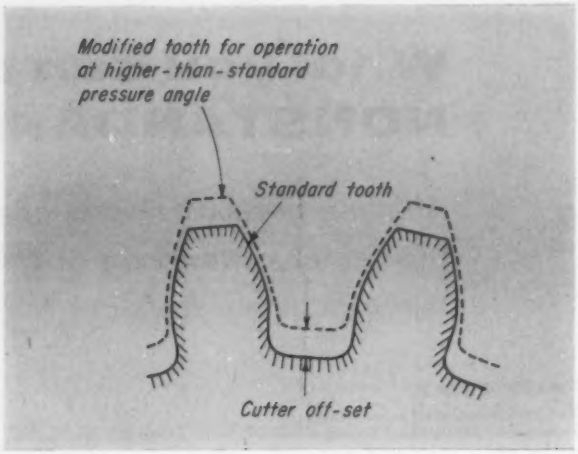


GEOMETRIC RELATIONSHIP (left) of operating pressure angles and center distances for a single planetary gear system (above) is the basis for effective use of nonstandard spur gears.

REPRINTED—Circle 619, inside back cover



NONSTANDARD spur gears in a double planetary gear system can boost the reduction ratio from 1:21 to 1:1600.



STANDARD tools can be used with predetermined cutter offset to generate nonstandard spur gears. Cutter offset shown will produce a modified tooth for operation at higher-than-standard pressure angle.

hand factor in the above equations cancel out so that:

$$C = \frac{N_s + N_p}{2P} \tag{3}$$

and

$$C = \frac{N_r - N_s}{2P} \tag{4}$$

This limits the freedom with which center distance C can be varied. Likewise, the gear ratio cannot be changed without varying the center distance.

By varying the pressure angle to suit particular design conditions nonstandard spur gears offer:

- Precise gear ratios and optimum meshing teeth combinations in a planetary system.
- Precise center distance for a given gear ratio.
- Very high speed ratios in a planetary system.
- Flexibility in choosing numbers of gear teeth in order to space planets equally.
- Flexibility in choosing numbers of gear teeth in order to de-phase the ratio of planets to the number of teeth in sun and ring gears.
- Operating pressure angle that will give the best compromise between high and low operating angles.

Precise gear ratios in a planetary system with standard spur gears are limited to the number of gear teeth that give a whole number for the planet gear teeth. For example, if a ring gear with 87 teeth and a sun gear with 28 teeth are specified, it would be impossible to find a planetary gear that would fit between them, because it would require 29½ teeth. With nonstandard spur gears, however, it is possible to use 28, 29, 30, or 31 teeth, simply by adjusting the operating pressure angles. In this case 28- and 30-tooth planets are not good choices, because of the common factor with the 28-tooth sun gear. The 29 tooth planet likewise is not a good choice because of the common factor with the 87-tooth ring gear. So this narrows the choice to the 31-tooth planet.

Eq (1) and (2) show that three operating pressure angles are involved. If the gears are selected with a manufactured pressure angle of 20 deg and a corresponding diametral pitch of 10, and if the operating pressure angle for the planet gear external mesh is assumed to be 18 deg, the remaining angle ϕ_i can be calculated as follows:

$$C = \frac{28 + 31}{2\,(10)} \frac{\cos 20^\circ}{\cos 18^\circ} = 2.92 \text{ in.}$$

Substituting this value of C in equation (2) gives:

$$\phi_i = \cos^{-1}\left[\frac{(87 - 31)\cos 20^\circ}{2\,(10)\,(2.92)}\right] = 25.49^\circ$$

Precise center distances can be maintained by merely varying the pressure angles, and this can be done without changing the gear ratios. This is particularly advantageous when errors in center distance need to be corrected without changing gear ratios. Also, there are occasions when precise center distances are more important than the specified gear ratios. Nonstandard spur gears could fulfill such requirements, and still give more exact gear ratios than is possible with standard spur gears.

Flexibility in choosing gear teeth numbers is also desirable in a planetary system in order to space the planets equally. This condition requires that the sum of the teeth in the ring gear and sun gear be divisible by the number of planets. This is a requirement that is not always easily fulfilled with standard spur gears without sacrificing desired gear ratios.

For example, assume that an approximate ratio can be satisfied with 142 teeth in the ring gear and 28 teeth in the sun gear. If three planets are to be used, then for equally spaced planets, the ring gear must have, as the closest approximation, 143 teeth; so that (143 + 28)/3 = 57. With nonstandard gears you could use 143 teeth, even though the tentative number of teeth in the planet is 57½.

Flexibility to de-phase the gear meshes is sometimes a problem that can be solved with nonstandard spur gears. This is a case where the number of planets must have no common factor with either the number of teeth in the sun gear, or the number of teeth in the ring gear. For example, in a planetary system with 33 teeth in the sun gear, 123 teeth in the ring gear and 3 planets, the unit could be de-phased by changing the sun gear to 31 and

the ring gear to 116. At the same time the original gear ratio can be maintained approximately.

Choosing the best operating pressure angle is sometimes an advantage by itself. In standard spur gears with either 14½ or 20-deg pressure angles it is a dilemma to choose between the advantages of low and high operating pressure angles. For power gearing of an operating pressure angle of about 25 deg is usually preferred. But in a planetary transmission this high angle is an advantage only at the external mesh since the load-carrying capacity of the internal mesh is inherently higher than the external mesh.

Usually, the rim of the ring gear is subjected to high bending stresses set up by the separating components of the planet gear-tooth loading. For a given value of the tangential tooth load, the bending stresses in the ring gear rim are directly proportional to the tangent of the operating pressure angle. This means that the stress in the ring gear rim increases by about 35% in going from 17 to 25-deg operating pressure angle.

Here is the procedure for designing a planetary system with operating pressure angles of about 17 deg for the internal meshes, and 25 deg for the external meshes. Assume that preliminary specifications call for a ring gear with 108 teeth, a sun gear with 42 teeth, and a diametral pitch of 10 corresponding to a pressure angle of 20 deg, then calculate:

Step (1) $N_p = \dfrac{N_r - N_s}{2} = \dfrac{108 - 42}{2} = 33$

Step (2) $C = \dfrac{N_p + N_s}{2P} \dfrac{\cos 20}{\cos 20} = \dfrac{33 + 42}{2\,(10)} = 3.75$ in.

Starting with these values, the final adjustments can be made to obtain the desired operating pressure angles as follows:

Step (3) $\phi_o = \cos^{-1}\left[\dfrac{N_p + N_s}{2P} \times \dfrac{\cos 20}{C}\right]$

$\phi_i = \cos^{-1}\left[\dfrac{N_r - N_s}{2P} \times \dfrac{\cos 20}{C}\right]$

First varying N_p, then C, and maintaining N_p and N_s the above equations give the following combinations:

N_p	C	ϕ_o	ϕ_i
33	3.750	20	20
32	3.750	22.00	17.78
31	3.750	23.84	15.26
31	3.760	24.19	15.81
31	3.775	24.69	16.59
31	**3.784**	**24.99**	**17.04**

This shows that the last combination in the above table is the closest that could be obtained for this example to take advantage of high operating pressure angle in the external meshes and low operating pressure angle in the internal meshes.

Very high speed ratios can be obtained with nonstandard spur gears in a double planetary system shown here. Mr. S. Rappaport showed in his article (*PE—Jun 22 '59, p 65*) how this trick can also be performed with a combination of spur and helical gears.

For standard spur gears the key relationships in this unit are:

$$R = \frac{1}{\left[1 - \dfrac{N_{p1} N_{s2}}{N_{p2} N_{s1}}\right]} \qquad (5)$$

$$N_{s1} + N_{p1} = N_{s2} + N_{p2} \qquad (6)$$

$$C = \frac{N_{s1} + N_{p1}}{2P} \frac{\cos \phi}{\cos \phi_1} \qquad (7)$$

$$\phi_2 = \cos^{-1}\left[\frac{N_{s2} + N_{p2}}{2P} \frac{\cos \phi}{C}\right] \qquad (8)$$

Eq (5) shows that very high ratios can be obtained by making the quantity $(N_{p1} N_{s2})/(N_{p2} N_{s1})$ approach unity. However, (6) shows that for standard spur gears the sums of teeth in the sun and planet of each planetary unit must be equal. On the other hand, with nonstandard gears by varying the pressure angle, Eq (7) and (8) can be used to arrive at suitable proportions. For example, a double planetary system with standard spur gears $N_{s1} = 41$, $N_{p1} = 40$, $N_{s2} = 40$, $N_{p2} = 41$ will give an approximate overall ratio:

$$R = \frac{1}{\left[1 - \dfrac{40 \times 40}{41 \times 41}\right]} = 21$$

But a double planetary system with nonstandard spur gears, $N_{s1} = 40$, $N_{p1} = 39$, $N_{s2} = 40$, $N_{p2} = 41$ will give, an approximate overall ratio:

$$R = \frac{1}{\left[1 - \dfrac{39 \times 41}{40 \times 40}\right]} = 1600$$

Typical operating pressure angles for this system can be determined from Eq (7) and (8). In this case they could be $\phi = 20°$, $\phi_1 = 23°$, $\phi_2 = 19.2°$ for $C = 4.040$ in.

Spur gears for such a double planetary system have an advantage over helical gears in that they do not introduce extraneous axial thrust loads.

What about the disadvantages?

Nonstandard spur gears are essentially custom designed to fulfill particular needs, and this usually means that they cost slightly more. However, properly designed, they can be made with standard tools in the same way as standard spur gears. The main difference is the degree of cutter offset required for the particular operating pressure angles and center distances selected to maintain the desired backlash (see diagram above, left). Several systematic methods are available for determining cutter offset and for proportioning the cutter offset (tooth thicknesses) to optimize the bending strength of the gear teeth.

For REPRINT of above article, just check 619 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: These articles give additional information on gear train problems:

When Helical Gears Get You Out of Tight Spots, Oct 17 '60, p 61—Shows how variation of helix angle makes these gears adaptable for many unusual problems.

Novel Concept Gives Record Gear Ratios, June 22 '59, p 67—Involves pairing helical with spur gears in standard planetary system to give exceedingly high ratios.

How to Predict Efficiency of Gear Trains, Aug 4 '58, p 44—New formulas and test data show how to compute power loss due to sliding action of involuate gear teeth.

Epicyclic Gear Systems, June 13 '60—Gives equations for calculating volume, power capacity, speed ratios and stresses for spur or helical gear trains.

Epicyclic Gear-train Calculations, Apr '57, p 186—Shows step-by-step calculation of forces and speeds, by reducing the train to its component parts and analyzing the center member.

—Frederick Marich

can you ignore

NUMERICAL CONTROL?

With simpler control systems and new production concepts, a wide variety of metal-shaping operations are now practical. Here's what has been happening in this fast-moving field.

A P LANGLOIS, *supervisor*
Applied Manufacturing Research
Convair Div of General Dynamics

■ Man's achievements have always been limited by his tools. That is why engineers are showing such active interest in numerical control. For the first time, designers can specify complex, but efficient shapes without paying a large cost penalty. And production volume need not be large—as few as 5 or 10 parts can often be made economically. Parts are delivered sooner too, because tape controlled machines require a minimum of jigs and fixtures.

But along with this new-found freedom come the inevitable problems. Drawings must be dimensioned differently. Additional information is needed to guide those who will prepare the tape for the machine. And despite their versatility, there are still some limitations in our ability to command their movements. Like any other machine tool, knowing what it does poorly and what it does well is the key to maximum efficiency.

Since introduction of the first automatically programmed machines in 1954, numerical control has spread to many areas of the production shop. Because the first machines were put to work hewing out large three-dimensional shapes for the aircraft industry, many engineers think of numerical control only in terms of multimillion-dollar machines. But simpler control systems and new production concepts have changed all that. Now we know that the idea of converting symbols on tape to physical dimensions is practical for many operations, from simple positioning to intricate contouring. Today, there are more than 2000 machines in use in this country and the number is growing rapidly. At last summer's machine-tool show in Chicago, manufacturers showed nearly 100 tape-controlled tools—punch presses, lathes, drill presses, milling machines, grinders.

Savings all around

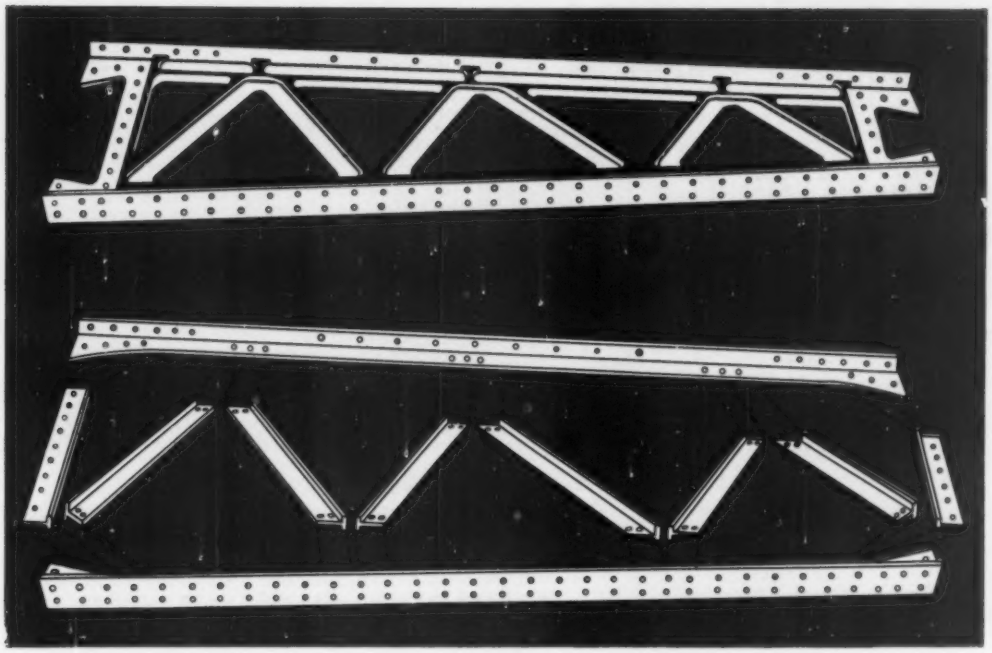
The repercussions of this growth on design have come from many directions. Most obvious is the reduction in production cost. It has been estimated that the control system itself will operate for about 30¢ per hour—cheaper than skilled labor anywhere in the world. Most of the expense is in preparing the tape for the machine, and in set-up time. A reduction in the number of jigs and fixtures is another cost saving. But more important to the designer, these pre-production savings mean an equivalent reduction in lead time. No longer is it necessary to wait for complicated tools and jigs. Now the designer can move from drawing to finished part in whatever time it takes to punch the tape and set up the tool.

Reduced cost and time—these are the obvious advantages of numerical control. But what direct effect does it have in the way the designer does his job? First there is the opportunity to explore designs that were previously considered impossible. Complex surfaces can now be cut from metal without special cams or intricate layouts. Built-up structures consisting of many individual parts, and requiring many individual drawings, can now be hogged out of a single slab (see sketch, next page). This not only saves drafting effort and reduces paperwork, it simplifies the tolerance problems since only the over-all tolerances need be specified.

Another auxiliary advantage is the uniformity of the parts produced. Because all the decisions—tool speed, feed, direction and depth of cut—are made in advance and punched into the tape, operator variables are eliminated. Each part is exactly like the previous one. This permits you to reduce the margin allowed for machine error and to make more efficient use of your materials. It also means more part reliability and less time for inspection.

Two variations on a theme

The extent to which a numerically controlled machine will affect design depends on the type of machine used.



THE INEXPENSIVE WAY to make this wing rib, Convair engineers found, is to rout it out of one piece of metal on a numerically controlled milling machine. Previously, the rib was assembled from individual extrusions and formed brackets. This required 420 separate drawings and tooling for each part. The one-piece ribs need only 84 detail drawings, reduce assembly time from 476 hours to 112, and provide a weight saving of 42 lb per airplane. They are machined four-at-a-time (two left and two right) to make a symmetrical form that saves programming time.

Basically, there are two types: point-to-point and continuous path. Point-to-point machines move the tool in straight lines from one specific location to the next. Their chief use is to produce parts that can be specified with a comparatively small number of rectangular coordinates. This, however, accounts for about 85% of the numerical control market, according to best industry estimates. More complex parts—those with irregular surfaces and non-linear outlines—call for a machine with the ability to move the tool in a continuous path (actually an extremely large number of discrete points).

Tape for a point-to-point machine is usually prepared on a manual tape punch. For continuous path machining, on the other hand, the tape is usually computer-prepared. With a computer doing the work, the input can be simply a short list of general instructions and equations that define the part. It will expand this information to produce the myriad individual instructions required by the machine tool.

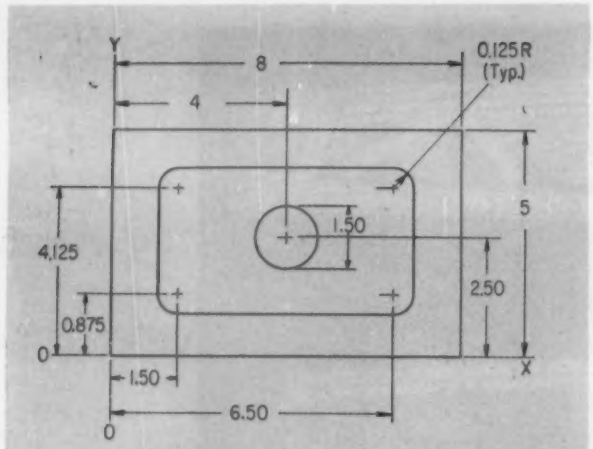
This programming job has recently been simplified with the development of computer programs that accept part descriptions written in an English-like language. APT (Automatic Programmed Tool) is one such program. Developed and approved by members of the Aerospace Industries Association, it is currently in use in many industries. In its present stage of development, it will produce a tape of machine instructions from an input vocabulary of 250 words. IBM's AUTOPROMPT program is a more recent development. It has a 110-word vocabulary and offers a much-simplified method of producing tapes for irregular 3-dimensional surfaces. A program of only a few hundred words generates thousands of machine instructions.

These new advances in the programming have many implications for the design engineer. Drawings can often be just a simple sketch and in some cases, there will be no need for a drawing at all. Equations and a few critical coordinates will give the programmer all he needs to prepare a complete tape. And to check the results without cutting metal, the tape can be fed into a verifier-plotter which will make an accurate engineering drawing in a fraction of the time needed for a hand-prepared drawing.

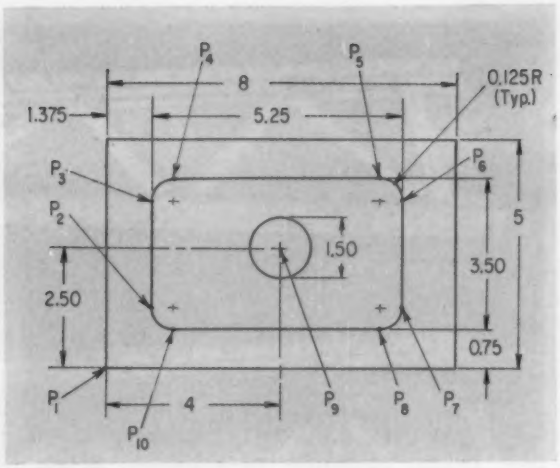
Revised drafting practices

For the most part, however, design for numerical control will still require drawings prepared by draftsmen. But drawings made to guide a programmer have to be different from drawings made to guide a machinist. The programmer will need to know where a straight line stops and a fillet radius begins, for example. He will need to know the points of inflection on curves and quadrant break points on circles. And to reduce programming errors, all dimensions should be provided in a system compatible with the numerically controlled machine.

Industry experts have yet to agree on a common dimensioning system. Some companies advocate complete conversion of present drafting practice to the Cartesian coordinate system. In this scheme, all dimensions are referenced to X and Y axes and a 0-0 point which may or may not be a



	X	Y
1	0	0
2	01.375	00.875
3	01.375	04.125
4	01.500	04.250
5	06.500	04.250
6	06.625	04.125
7	06.625	00.875
8	06.500	00.750
9	04.000	02.500
10	01.500	00.750



EITHER OF THESE DRAWINGS is acceptable for numerically controlled production. The one at left is dimensioned in the usual way, but also includes the X-Y coordinates of each point of interest to the programmer. The one at right has Cartesian coordinate dimensions referenced to the X-Y axes with 0-0 point at lower left-hand corner or part.

physical point on the part. The other solution is to provide dimensions in the conventional manner and add whatever detail information is needed by the programmer (see sketch above).

Whatever the drawing system, it is essential that the part lie in the first quadrant so that dimensions are expressed in positive numbers with respect to some arbitrary X and Y axes. None of the positioning control systems to date will recognize negative dimensions. If they appear on the drawing, the programmer will be obliged to translate the axes, with consequent risk of human error. Also, all positioning dimensions should carry the same tolerance so far as is possible and the tolerance should straddle the nominal dimension. If there are a variety of tolerances, the programmer will have to make adjustments in his calculations. This runs the risk of permitting still another opportunity for mathematical error.

Other phases of design for numerical control are not unlike designing for conventional production machines. But those practices that increase efficiency in normal production are even more effective in numerically controlled production. Here are some examples:

- Specify the same fillet radius for all rounded curves on the same part. This reduces the number of cutting tools and the number of programming steps.
- Design for symmetry wherever possible. This way, the right and left sides of the part can be made from the same program.
- Take advantage of close tolerances and part uniformity to achieve maximum strength-to-weight ratio.
- Aim for minimum number of machine setups. Eliminating one unessential cut will sometimes avoid a costly, time-consuming setup.
- Specify same tap and drill sizes wherever possible.
- Avoid blind, tapped holes and back spot-facing operations.
- Design for stress-relieved stock when suitable. This ensures that the material will remain stable during machining.

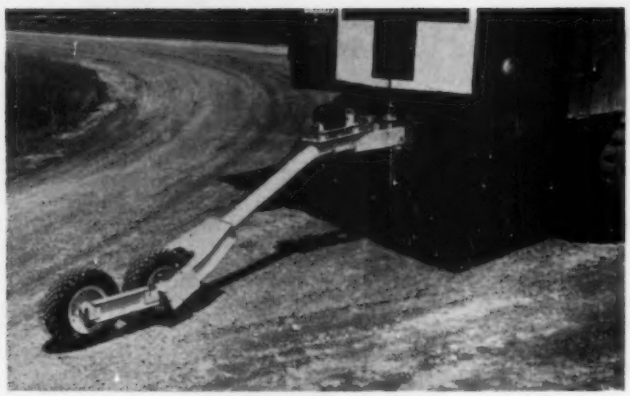
One misunderstanding that still persists is that numerical control is only justified for complicated, expensive parts where the large savings are self-evident. However true this argument may be, small parts are also practical. In fact, small parts have a significant advantage: they permit experimentation without risk of an expensive error. And errors will occur. Despite the machine's elaborate controls and the programmer's error-detection measures, tape-controlled machines are not self-correcting. Careful design and sound engineering practice are still the essential ingredients of a successful product. ■

EDITORS NOTE: For more about numerical control, what it can do and how it works, see:

Numerical Control and the Design Engineer, Oct 20 '58, p 23—How design steps for numercial control compare with those for conventional machining.

Numerical Control—Where it's Going . . . What it's Doing, Oct 27 '58, p 50—A summary of the different types of control systems and how they work.

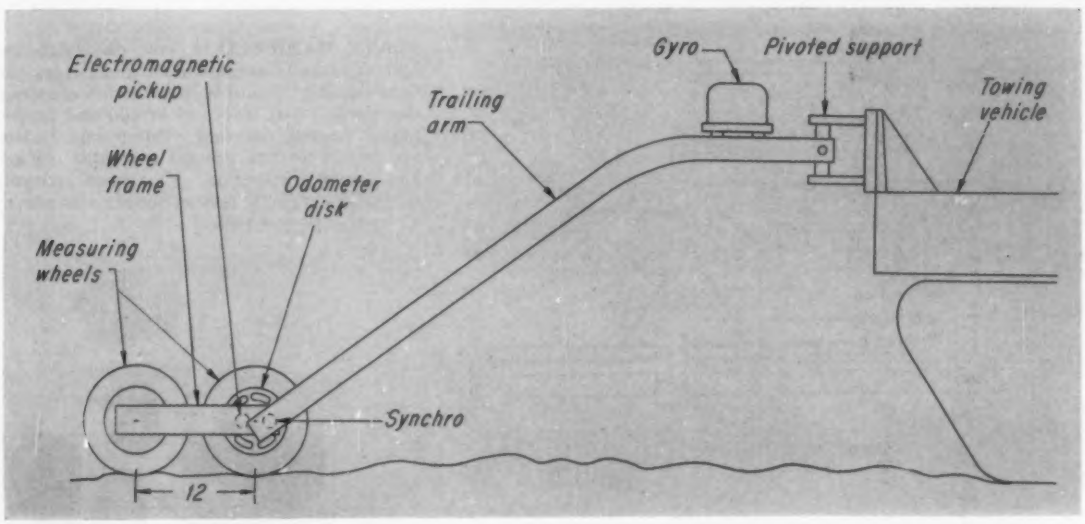
—Charles J Lynch



DISTANCE traveled and slope of the ground are measured continuously as test vehicle is in motion. Trailing arm supports a two-wheel measuring assembly tandem mounted to follow a common track. An angular reference device on the trailing arm provides a continuous indication of the pitch angle of the wheel frame, which is assumed to be the same as the slope of the ground. Distance traveled is measured by an odometer connected to one of the wheels.

Trailing wheels record ground condition

Measuring assembly records the slope of the ground and distance traveled along the surface. Integrating the slope of the ground with respect to distance traveled provides the data needed to evaluate terrain over which off-the-road locomotion systems are tested.



TERRAIN MEASURING SYSTEM is connected to the test vehicle by means of a pivoted arm which allows it to rotate in both pitch and yaw. The slope of the ground is sensed by a pair of 11-in. wheels tandem mounted on a frame of 12-in. wheelbase. The odometer consists of a slotted metal disk mounted on the front measuring wheel plus an electromagnetic pickup. As the slots pass the pickup a voltage pulse is produced, amplified and used to trip a relay. The pulses produced indicate an increment of travel of the measuring wheel. The voltage pulses transmitted through the relay are recorded on magnetic tape.

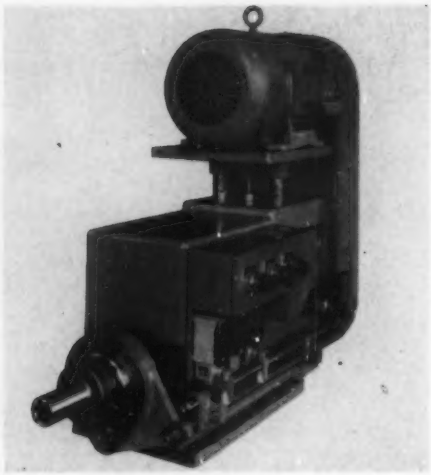
Two synchros indicate the pitch angle of the wheel frame from the vertical. One synchro indicates the angle between the wheel frame and the trailing arm. The second synchro is attached to the pitch gymbal of a vertical gyro on the trailing arm and measures the angle between the trailing arm and the vertical spin axis of the gyro. The two synchros are interconnected so that the sum of the output voltages is proportional to the sine of the angle between the wheel frame and the vertical. The output signal (400 cps) is demodulated to a varying dc voltage. The magnitude and sign of the dc voltage is recorded on magnetic tape in parallel with the odometer pulses.

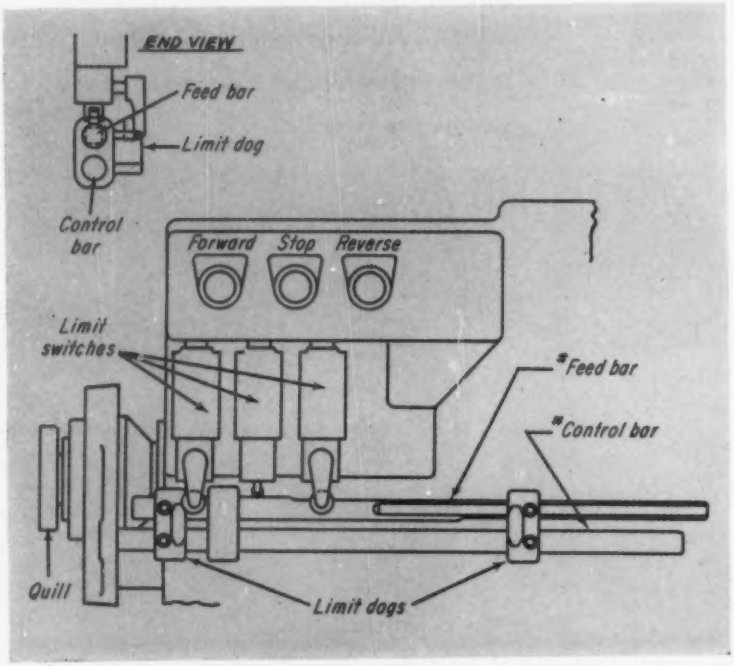
PS . . . To design vehicles with improved rough-ground performance, methods must be developed to analyze and predict performance precisely. This instrument system is used to collect the necessary information on terrain geometry. Accuracy is better than 1 in. over horizontal distances equivalent to vehicle wheelbase length and 4 in. over distances of 100 ft. Terrain measuring assembly was developed by the Institute of Science and Technology of the University of Michigan under sponsorship of the Land Locomotion Laboratory, Ordnance Tank-Automotive Command of the US Army.

—Felix Giordano, Detroit

Mounting-plate manifold eliminates piping

Self-contained drill unit uses stock parts for maximum building-block flexibility. Multipurpose parts simplify assembly to suit customer's application.





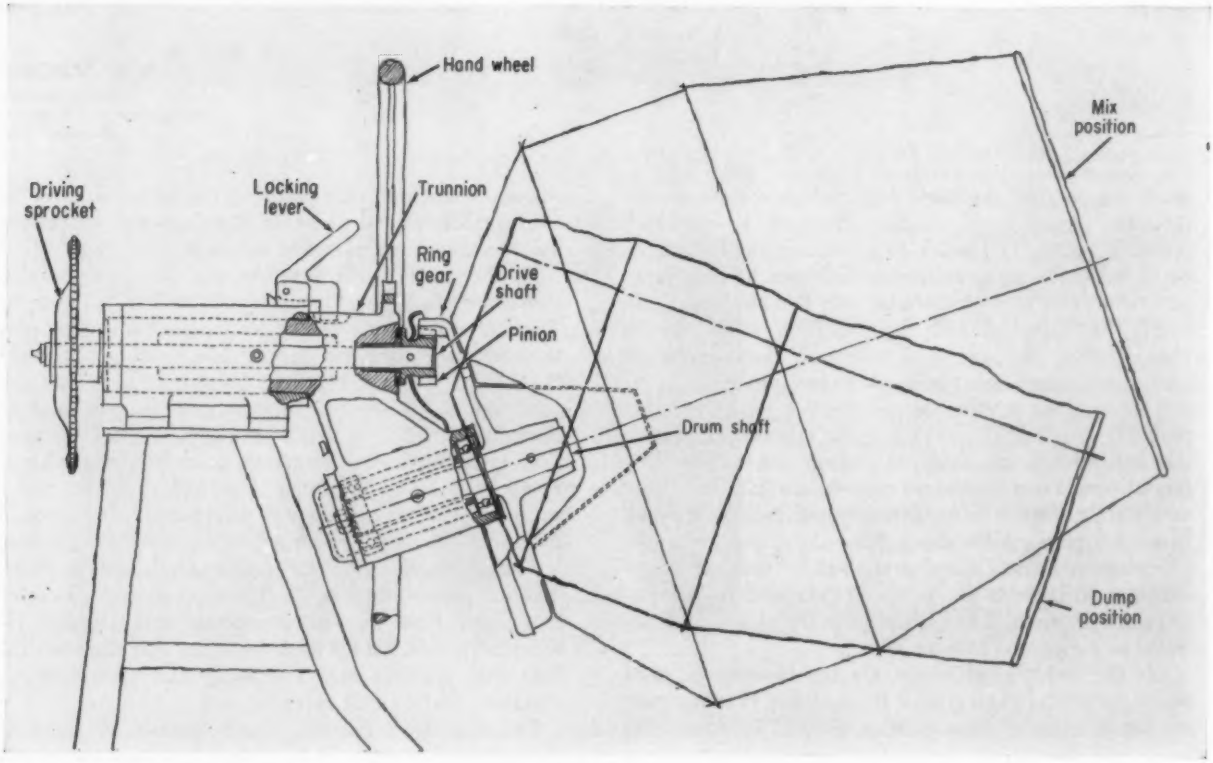
FEED AND RAPID TRAVERSE of quill are set by positioning two limit dogs and the feed bar. The front dog trips the front limit switch to halt return motion of the quill. Rear dog and switch determine limit of the feed stroke. The feed bar sets the point at which the rapid traverse ends and feed cycle starts. Four flats, ground on the round feed bar, offer four different feed-stroke lengths. Limit switches actuate the solenoid valves which control fluid flow to the feed cylinder.

PLATE MANIFOLD is base on which the hydraulic units are mounted and covers the base casting. Manifold is sandwich construction made up of layers of drilled and tapped plates brazed together. Pump and valves are bolted to the ground manifold surface and sealed by O-rings. Cast base contains quill and hydraulic feed cylinder; also serves as hydraulic reservoir.

PS . . . Controls, pump, motors, etc, for this drillhead are off-the-shelf components obtainable from local stocks. The 5-hp (max) unit has a 12-in. stroke, ½ to 60 in./min feed range with spindle speeds from 296 to 3200 rpm. The Gerabi drill unit is produced by Special Machine and Engineering Inc, Southfield, Mich. —Felix Giordano, Detroit

Hanging drum swings to discharge

Concrete mixing drum is rotated around its offset shaft to dump concrete. Enclosed drive gears are protected from the effects of abrasive slurries.



MIXER DRUM swings on a hollow trunnion mounted in a bearing block on the tubular frame. Drive shaft passes through the trunnion to drive a beveled pinion and internal ring gear set. Mixer drum is bolted to the outer surface of the internal ring gear and rotates with it. Ring gear and drum are supported in ball bearings in the lower half of the trunnion casting.

In operation the mixer is loaded in the mix position and rotated until the slurry reaches the desired consistency. To discharge the mix the locking lever is raised and the hand wheel is rotated. This swings the drum around the trunnion center line to the discharge position. Drive pinion and ring gear remain in contact and the drum continues to rotate to speed discharge.

PS . . . The 2-cu-ft mixer is chain driven by either a 1.1-hp gas engine or ¾-hp electric motor. All welded unit weighs approx 350 lb and can be wheeled around by one man. The 14-in. pneumatic wheels and tow bar permit the unit to be towed at moderate speeds. The 2-T concrete mixer is produced by Winget Ltd, Rochester, Kent, England. —John Tunstall, London

HOW GOOD ARE INEXPENSIVE PHOTODRAWINGS?

Good enough for most applications, according to this author. He couldn't afford the expensive equipment needed for top-quality photodrawings, so he experimented with standard drafting materials. Here's what he found.

B W SCHOBIN
Design engineer
The Hamilton Tool Company
Hamilton, Ohio

■ If you demand the "best possible" photodrawing, the methods presented in another PRODUCT ENGINEERING article ("Latest Technique in Camera-made Drawings," Sep 5 '60, p 58) are undoubtedly the choice for your drafting room. But many small firms may find they need relatively few drawings, and their drafting time may be cheaper than the expensive materials and equipment needed to produce first quality photodrawings.

That was the problem we faced. We recognized that photodrawings would save time in our manufacturing cycle (the assembly of special-purpose, rotary, web-fed, printing presses from a combination of more-or-less stock units) but we couldn't afford to follow the recommendations of photodrawing experts. After some study and experimentation, I developed a less expensive method to produce photodrawings far superior to, and much cheaper than, the previous line drawings. The basic steps in the process are illustrated in the photos on next page.

For the best photodrawings, say the experts, you must adjust the master photographic transparency to compensate for the "contrasty" diazo printing process. Otherwise the prints will be blotchy: greys reproduce as blacks, or as whites, with few intermediate tones. They recommend two ways to adjust photos: either "screen" the continuous-tone picture, or make positive transparencies with a controlled-contrast electronic printer that matches the contrast range of the photograph to that of the diazo print paper. Both methods are expensive.

What happens if you don't adjust the photograph? We have found that you can make acceptable prints, without adjusting, if you start with a reasonably good photograph and use high-quality diazo print paper.

First, we have a local photographer take pictures of each machine that will be included in the photodrawing of the composite machine. He positions his camera so that the finished pictures will all be the same size and perspective. Two floodlights are placed to minimize "hot spots."

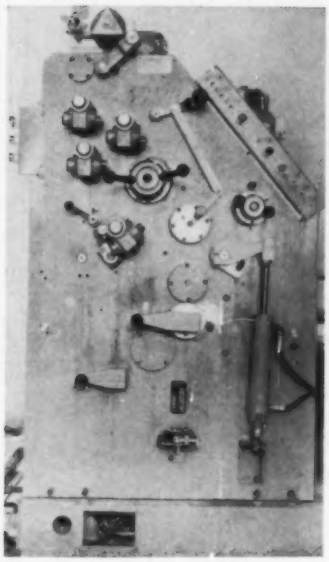
He then enlarges the negatives to a fixed dimension on a mat-surface Mylar film (Dupont Adhex or Eastman Translite). We make second-generation transparent positives from these masters on our diazo machine; Dietzgen F-247 E-3C or Ozalid 102 PC 3 transparent films both give good results. Contrast of these second positives must be carefully controlled so that each will have about the same shading on the finished composite print. Several trials may be necessary. I usually cut an 18 x 24 in. sheet into 6 or 8 strips and process each strip at different printing speed. I then mark the correct speed setting on the master positive.

The remaining steps are similar to the usual photodrawing procedure. The draftsman eradicates unwanted background from the second positives with acetone. He adds dimensions, hidden lines and notes, and assembles the individual positives into a drawing that represents the complete, custom-built machine.

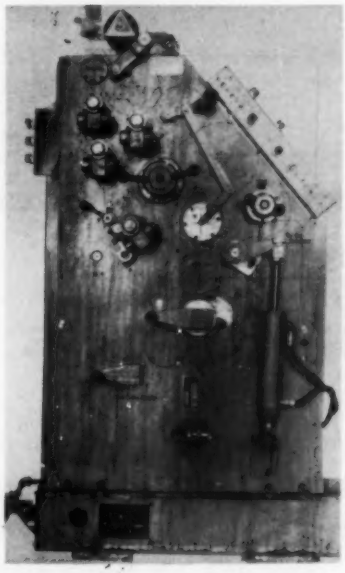
The time from finished master positive to complete photodrawing is about 1½ to 2 days. But once the second positive is made and the linework complete, it takes only about 1½ hours to assemble the parts into a finished photodrawing. So, by assembling, disassembling and reassembling the same second positives in different arrangements, we can prepare prints for a variety of machines with a saving in drafting time of about 95%.

Our photographer's fee is approximately $12.50 per finished positive and the second positives cost about $1 apiece. This, plus drafting cost of about $18 per second positive, brings the total cost to about $31.50. Because these finished positives are on heavy, durable film, they can be used and reused for prints almost indefinitely. ■

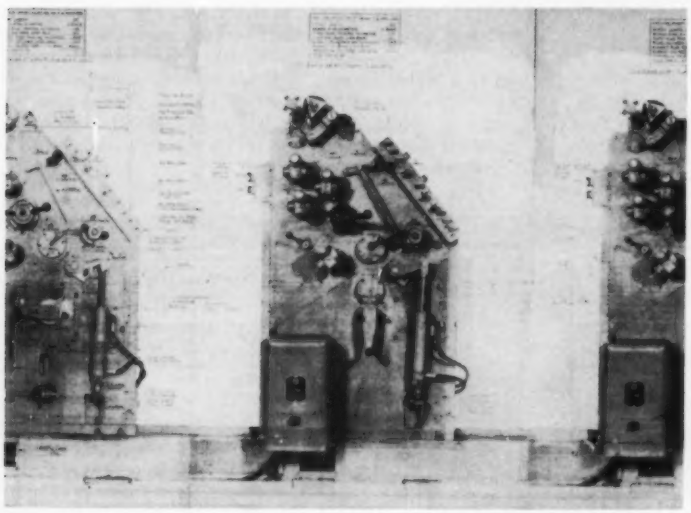
PHOTODRAWING—4 stages in its development



1



2



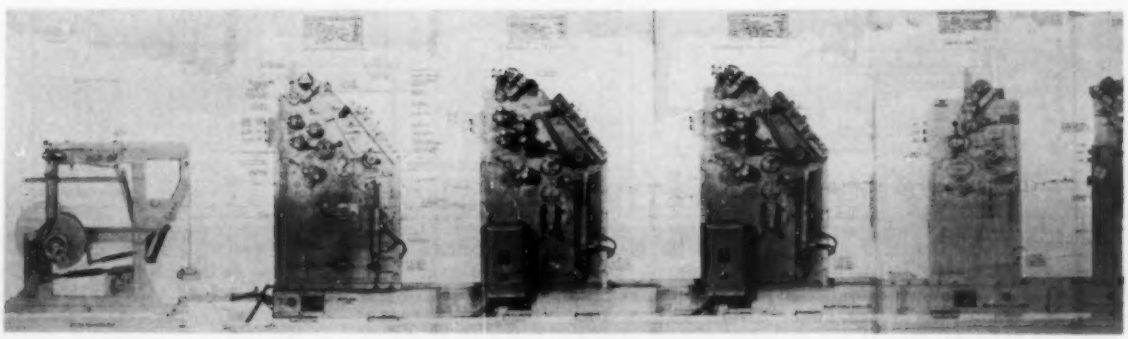
3

1 . . MASTER POSITIVE is simply a photograph of the machine enlarged to a specific dimension on Mylar film.

2 . . PARTLY COMPLETED SECOND POSITIVE shows some deterioration of detail (aggravated by the screening process used in printing this magazine) but most of the important details remain clear and sharp. At this point, the draftsman has eradicated the distracting background and added some of the hidden lines.

3 . . ASSEMBLED SECOND POSITIVES form a complete protodrawing. The draftsman has added all notes and dimensions, and shown connections between this unit and other parts of the complete machine.

4 . . BLUE-LINE PRINT of the assembled photodrawing is sharp and readable. The Hamilton Tool Company can prepare these complete drawings in only 1/20th the time required for line drawings.



4

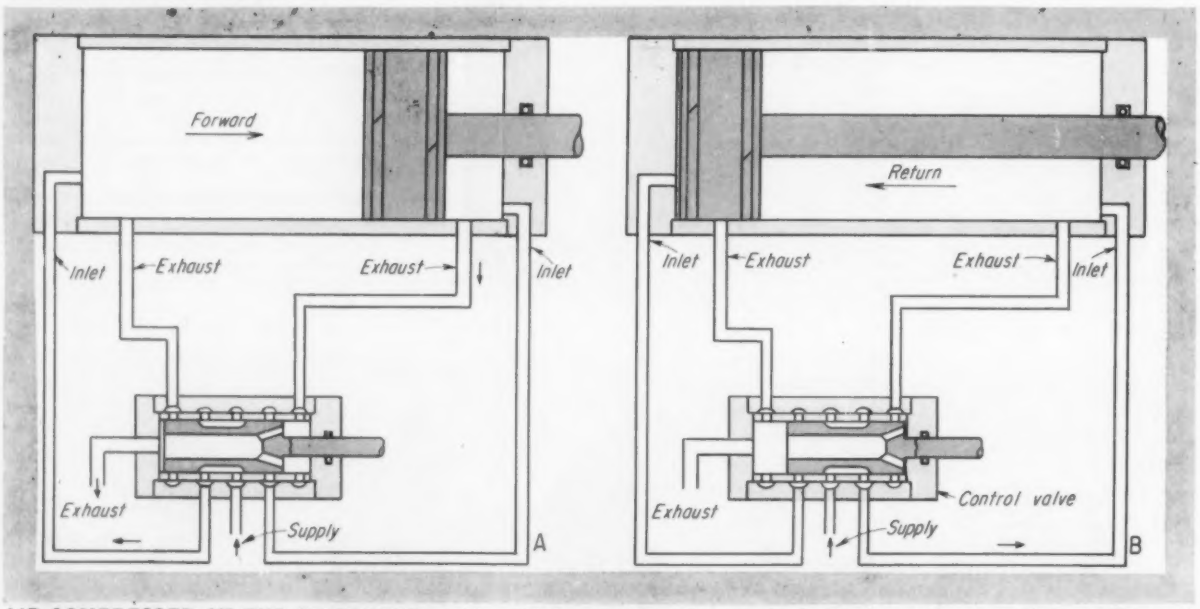
for cushioning and control of air cylinders,

REGULATE THE EXHAUST

Regulating the exhaust of an air cylinder creates a pressure which resists the forward movement of the piston. If you control this back pressure, you can greatly increase the usefulness of the actuator, especially for many high-speed applications. Here are three simple ways to use back pressure.

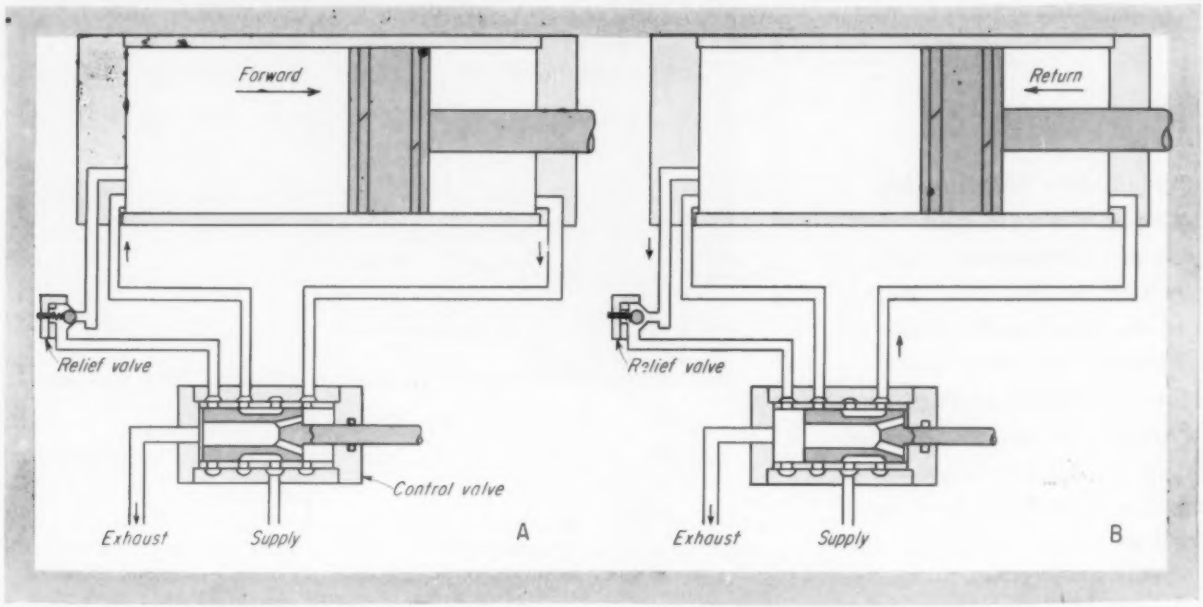
B A BOGGS
Lucasville, Ohio

CUSHIONED STOPS



AIR COMPRESSED AT END OF STROKE cushions high-speed pistons. On forward stroke (A) piston moves at full force. At the end of the stroke, piston covers exhaust port to compress air remaining in the cylinder. Return stroke (B) shows piston blocking exhaust port for similar cushioning action. Exhaust ports can be located any desired distance from end of cylinder as long as distance does not exceed three-quarters of piston length. Because of pressure build-up in inlet line during cushioning, control valve should be as close as possible to the cylinder. Volume of this inlet line must be considered part of cylinder volume when calculating cushioning pressure.

TWO-FORCE, TWO-STROKE MOTION



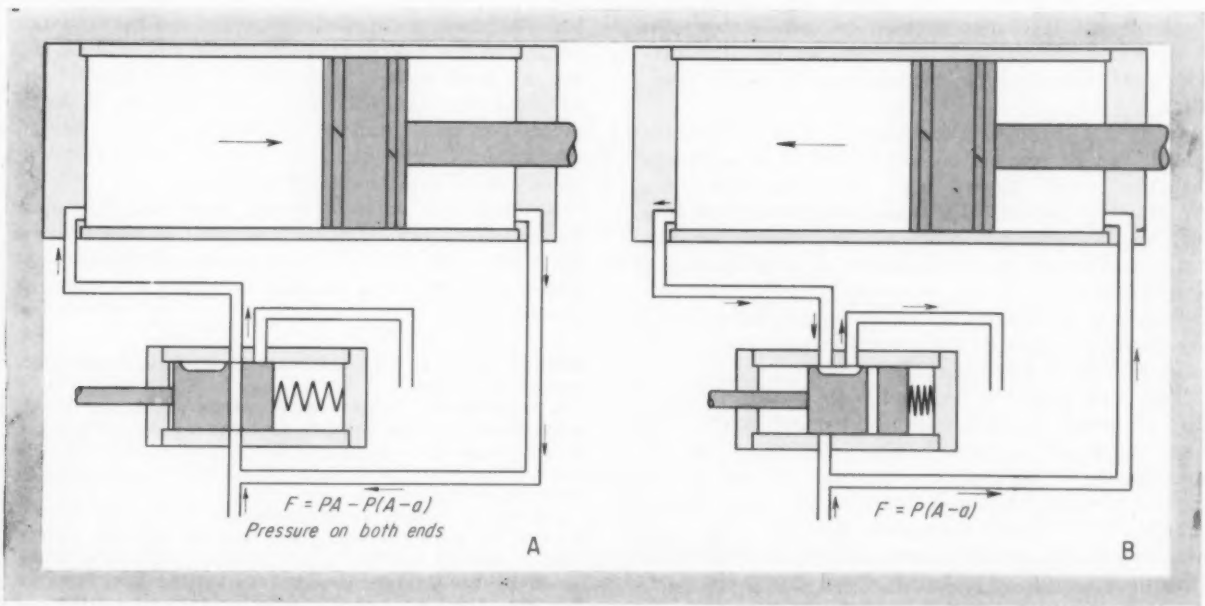
ADJUSTABLE DIFFERENTIAL FORCE for linear movement with a specified force in one direction and a different force in the return direction. Difference in the two forces can be controlled by relief-valve setting.

Relief valve is set so that return stroke will be resisted by known back pressure. On forward stroke (A), no resistance is met because exhaust through control valve is unrestricted, and piston moves forward with force equal to supply pressure times piston area. When piston reaches end of forward stroke, valve is moved to second position (B) which opens special exhaust port through relief valve. Supply is shifted to opposite side, and piston moves on return stroke.

Force in return direction is

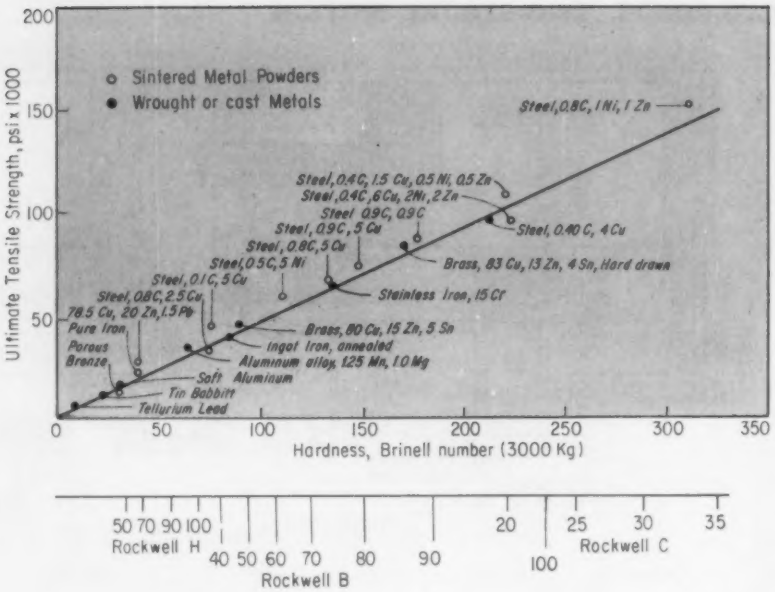
$$F_r = (A—a)\ P—AP_b$$

where A is area of piston, sq. in.; a is area of piston rod, sq. in.; (A—a) is differential area; P is inlet pressure, psi; and P_b is back pressure, psi. Both supply and back pressure can be varied, so either stroke is adjustable.



FIXED DIFFERENTIAL FORCE. As above, different forces are needed in each direction. In this circuit, however, no relief valve is required. Same pressure is applied to both sides of the piston at once causing forward stroke (A) to be a function of piston rod diameter. For return stroke (B) left side of cylinder is exhausted to atmosphere through control valve. Piston rod must be proportioned to produce desired force differential, and no adjustment is possible.

Straight-line relationship between strength and hardness is characteristic of wrought metals, cast metals and sintered metal powders. Entering the chart with required tensile strength, (right) you can find Brinell or Rockwell hardness—a good production check as well as . . .



a new way to specify STRENGTH OF METAL-POWDER PARTS

R TALMAGE, *powder metallurgy consultant*
H L KEE, *assistant editor*

■ The remarkable correlation between hardness and tensile strength shown in this chart provides an easy-to-find index to strength or quality of a sintered-metal part.

The method is limited to metals that consist of a single phase. It cannot be used for non-homogeneous steels over 0.9% carbon or for metal-powder composites with slow diffusing alloys that produce segregated structures.

Up to now, hardness specifications were not considered reliable because readings on test batches of metal-powder materials usually showed poor correlation with other mechanical properties. The same test performed on samples from large-scale production runs at a number of plants has proved otherwise—that hardness is an accurate and reliable test of mechanical properties. Further, the tests showed that the linear relationship between Brinell hardness and tensile strength is the same for metal-powder parts as for wrought or cast materials.

The chart plots the relationship for both. It shows that the tensile strength is nearly, but not exactly, 500 times the Brinell hardness number. Differences in relative density of metal-powder materials do not change the linear plot. Although low density lowers tensile strength, it also lowers hardness in the same proportion. Materials plotted include relative densities that vary from 70% to 100%.

Notable exceptions to this tensile-hardness linearity are high-carbon steels (with more than 0.9% carbon) and cemented carbides in which the binder does not dissolve into the carbide particle. Conventional materials have similar exceptions. An example is cast iron—its excess of carbon segregates out in the form of graphite.

It is better to specify hardness for sintered parts by one of the Rockwell scales rather than by the Brinell number. Although their relation to tensile strength is not linear, the test indentations are quickly and easily made, and are small enough to be used on finished parts. In addition, the localized area tested by the Rockwell indentation is a check of production quality. Several readings on different areas of a metal power part will quickly reveal if metal density is uniform.

Rockwell tests, however, require more care—parts must be flat and smooth, particularly on the side supported by the anvil. Also, Rockwell hardness testers must be calibrated each time the machine is used for a different material or part. ■

EDITOR'S NOTE: For additional design data on sintered-powder parts, see:

- **For Stronger, Tougher Metal-powder Parts,** Mar 13 '61, p 78—Sintering iron powders to densities over 90% gives greater accuracy. Higher strength and ductility enable these high-density parts to do jobs formerly restricted to wrought or cast metals.
- **Guide to Specifying Metal-powder Parts,** July 25 '60, p 56—How much the part costs depends not only on the kind of powder but how much porosity you can tolerate.
- **How to Choose—Investment Casting or Sintered Powder,** June 8 '59, p 86—Although investment casting and sintered metal powder seem competitive for making small parts, a closer look makes the choice easier.
- **Design for Metal-powder Parts,** Aug '57, p 183—Basics on how to design shapes for the cold-pressing process.

DESIGNING FLAT SPRINGS— unit resilience and spring-rate

The factors that fit these 8 single and leaf springs to the nomographs also furnish a ready means of comparison. Two other nomographs, for width and thickness, appeared in the July 17 issue.

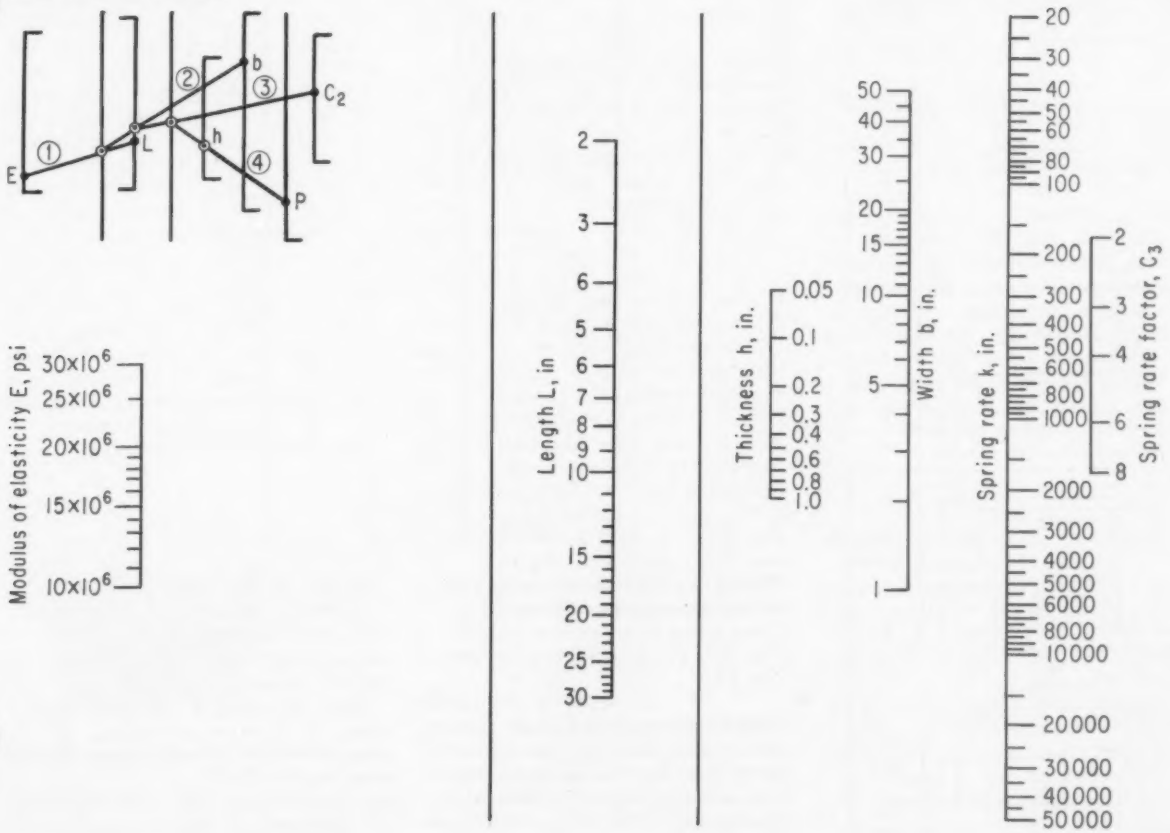
WILLIAM GRIFFEL, *Ordnance engineer, Picatinny Arsenal*

■ Unit resilience is the amount of energy a cubic inch of material absorbs when stressed to its elastic limit. For springs it is a measure of how much impact a spring can take. Note in the table of resilience factors that constant-strength springs (B, C, E to H) have three times the energy-storage capacity of constant cross-section springs (A and D). This is because constant-strength springs have smaller volumes and deflect farther under the same load, ie, are softer. Since unit resilence $R' = Fy/2V$, the result is a higher energy-storage capacity. The nomograph is based on another form of the equation $R' = S^2/C_2E$.

Spring-rate factors, by providing a direct comparison of spring rates, show that constant-strength springs are softer. Among both cantilever springs and simple-beam springs, constant-strength types have higher spring-rate factors, C_3. Thus spring rate $k = Ebh^3/C_3L^3$ is lower.

continued on page 46

I-SPRING RATE

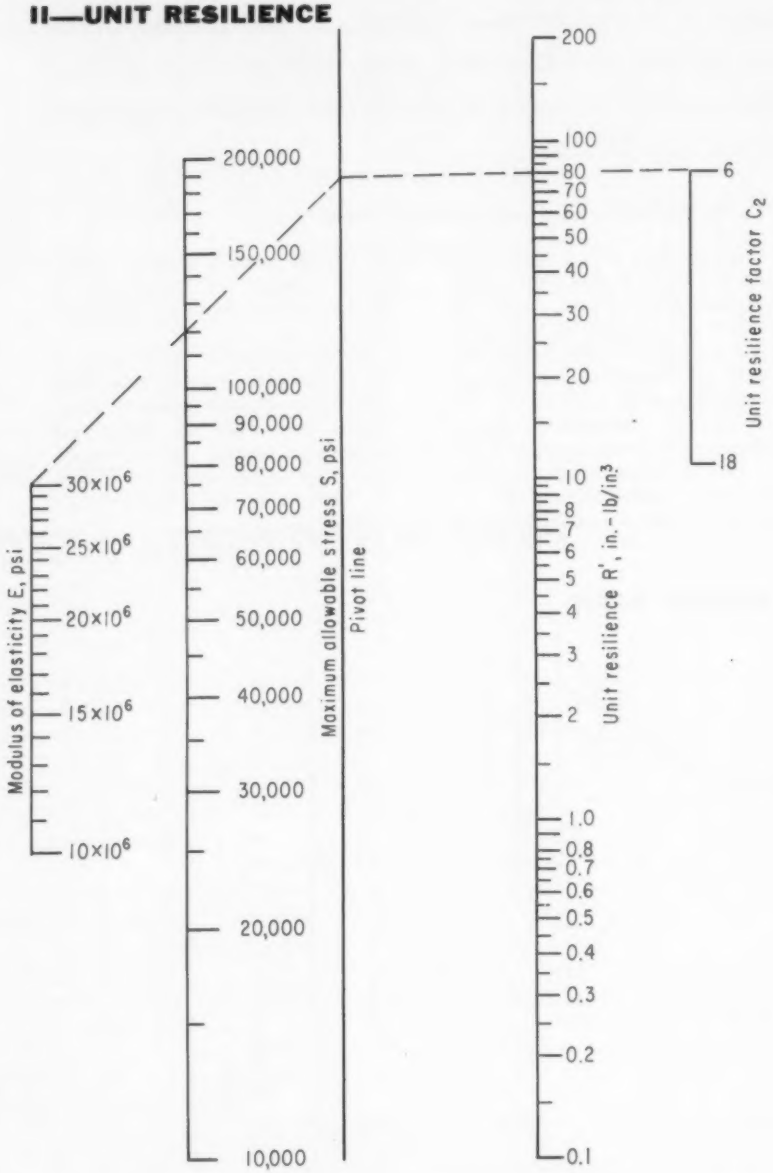


SYMBOLS

b	= Spring width, in.	L	= Length of cantilever spring; half-length of simple beam spring, in.
C_2	= Resilience factor	R'	= Unit resilience, in.-lb/in.^{3}
C_3	= Spring-rate factor	S	= Maximum allowable stress, psi
E	= Modulus of elasticity, psi	V	= Volume of spring, in.^{3}
F	= Load, lb	y	= Deflection of spring, in.
h	= Thickness of spring, in.		
k	= Spring-rate, lb/in.		

	C_2	C_3
A	18	4
B	6	6
C	6	8
D	18	2
E	6	3
F	6	4
G	6	6
H	6	3

II—UNIT RESILIENCE



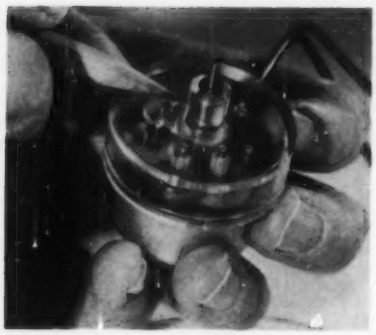
EXAMPLE: What is the spring rate and energy-storage capacity for a Type H leaf spring for which $S = 120{,}000$, $E = 30 \times 10^6$, $L = 13$, b = 2.4 and $h = 0.22$?

SOLUTION: Find spring-rate factor $C_3 = 3$ in the table. Also knowing b, h and E, draw four lines on Nomograph 1 to find spring rate $k = 140$ (148.5 by sliderule.)

Energy storage capacity = $R'V$. First solve for unit resilience. From the table, resilience factor $C_2 = 6$. Enter the nomograph with C_2, S and E. Draw two lines to find $R' = 80$.

Since this spring is like a type E spring cut in strips and stacked, calculate the volume of both springs the same way: $V = 5bLh = 5 \times 2.4 \times 13 \times 0.22 = 34.32$ in.^{3} $R'V = 80 \times 34.32 = 2746$ in.-lb.

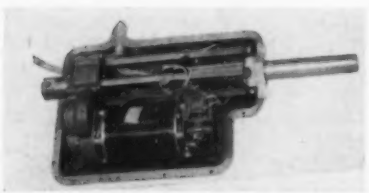
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Oil-filled synchronous timing motor . . .

incorporates a spring-loaded packing gland which prevents oil from working out of the housing when motor is operating. Key element of the packing gland is a neoprene O-ring, which is held under constant pressure by a spring, thus sealing in the oil. In addition to halting wear on working parts, mineral oil lubricant in motor housing allows silent operation. Other key components of motor, also submerged in oil, include a variable pole arm which provides starting reliability when rotor poles are stopped at dead center and a magnetic directional device which maintains proper rotation of the gear when motor is energized. Unit has torque output of 12 in.-oz at 90 v. Max power input is 3 w, and temp rise is said to be extremely low. Min speed is ¼ rpm. Outside diameter measures only 1 11/16 in., or ¼ in. smaller than conventional synchronous motor. Available completely or partially filled with oil. Partially-filled motor is priced at less than $2; other, approx $3 in production quantities. Delivery in 8 to 10 wk. **Lake City Inc, Sub of Controls Co of America, 110 W Woodstock St, Crystal Lake, Ill.**

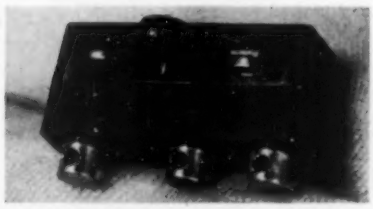
Circle 300 on Reader Service Card



Heavy-duty linear actuator . . .

has rated thrust of 500 lb tension and compression, with max thrust of 1000 lb. Its positioning accuracy is repeatable to within 0.0025 in. without feedback. Also has continuously adjustable stroke of from 0 to 6 in. with optional potentiometer for position indication, a capacitor start-and-run and a reversible single-phase motor with integral brake. Unit is entirely enclosed and offers provision for emergency hand operation. Currently available in small quantities at $200 to $300 each. **Lear Inc, Electro-Mechanical Div, 110 Ionia Ave NW, Grand Rapids 2, Mich.**

Circle 301 on Reader Service Card



Subminiature snap-action switch . . .

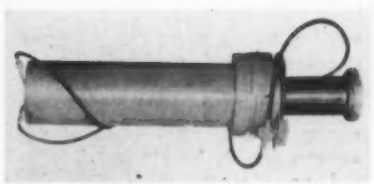
works through "cricket" action which involves only two moving parts—leaf spring and pushbutton to actuate it. The snap-action cricket spring carrying the movable contact provides high contact pressure and a contact wiping action in both make and break operations. Spring is said to have uniform stress distribution which reduces metal fatigue. Basic unit is SPDT type with drilled or turret terminals and a variety of toggle, pushbutton and lever actuators. Two- and three-gang assemblies are available. Rated 5 amp at 125/250 v ac on inductive and resistive loads; 4 amp at 30 v dc on resistive loads; or 2.5 amp at 30 v dc on inductive loads to 50,000-ft altitudes. Weighs less than 0.080 oz. High-impact plastic case consists of base with terminals molded in position and cap that accurately positions pushbutton actuator. Base and cap are plastic-welded into single unit that maintains a ±0.002-in. max tolerance on all mounting dimensions. From stock at $1.50 each. **Fansteel Metallurgical Corp, Contacts & Specialties Div, North Chicago, Ill.**

Circle 302 on Reader Service Card

Magnetic pickup . . .

generates useful voltage when excited by magnetic metal objects—even when moving very slowly through the magnetic field surrounding its sensing end. As a self-generating input transducer, unit provides a connecting link between mechanical motion and instrumentation without mechanical contact. When a gear tooth, pin, or any other ferrous metal projection interrupts the external magnetic field, the pickup generates voltage and current that actuates electrical or electronic circuitry without amplification and without additional power sources. Can be used with gear teeth of 20 pitch or greater and generates voltage/frequency in proportion to speed of metal teeth interrupting its magnetic field. Power is ample to operate many readout devices. Unit is encased in stainless steel shell and weighs 1.73 oz. Priced at $48.50. **Electro Products Laboratories Inc, 4500 N Ravenswood Ave, Chicago 40.**

Circle 303 on Reader Service Card



Hydraulic rams . . .

are heavy-duty, double-acting, threaded or unthreaded rams with capacities ranging from 10 tons up to and including 1000 tons. Used for prestressing, lifting, pushing applications or for sustaining full loads for long periods of time, they have infinite locking increments at any position. Available with manual or remote control safety locknut which protects against loss of hydraulic pressure. Can be locked in either direction of ram travel under full load. **Wm S Pine Inc, 1635 E 22nd St, Los Angeles 11.**

Circle 304 on Reader Service Card

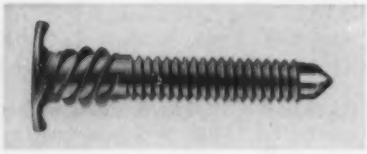
Pressure cell . . .

precisely measures fluid pressures in wide range of applications. SR-4 foil strain gages are said to provide highest possible stability and accuracy over wide temp ranges and minimize effects of transducer warmup, even at increased input voltages. Fully active, four-arm Wheatstone Bridge provides an output sensitivity of 3 mv/v at relatively low stress levels. Direct bonding of gages to pressure-sensing element eliminates loss of accuracy that may re-

continued on page 48

sult from linkages, pistons, diaphragms or other mechanical actuators and assures low sensitivity to shock and vibration. Printed circuit resistors, tapped at discreet resistance points, eliminate winding required by bobbin resistors if field adjustments are necessary. Cells are calibrated to an accuracy of 0.15 of 1%. Terminal linearity is within 0.2 of 1% and "best-fit-through zero" linearity is within 0.1 of 1% of full scale output. Available in 11 capacities from 0 to 100 psi through 0 to 10,000 psi. **Electronics & Instrumentation Div, Baldwin-Lima-Hamilton Corp, 42 4th Ave, Waltham 54, Mass.**

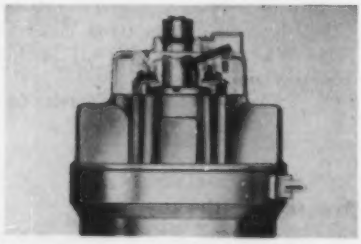
Circle 305 on Reader Service Card



Mounting screws . . .

in either wafer or flat-head style, eliminate need for countersinking to obtain flush mountings. Have multiple thread left-hand retaining sections and torque increasing "nibs" under head to prevent stripping in panels and to eliminate need for retaining nuts. Lead-in cone and smooth cylindrical section brings nut into mating position with thread. Flat-head screw is suitable for plywood $\frac{3}{8}$ in. thick and up. Lengths range from $1\frac{1}{4}$ to $1\frac{3}{4}$ in. Wafer head screw can be used with plywood, masonite or composition board $\frac{1}{16}$ in. thick and more. Also suitable for use with punched holes and available in lengths from $\frac{3}{4}$ to $1\frac{3}{16}$ in. From stock. **Shakeproof Div, Illinois Tool Works, St Charles Rd, Elgin, Ill.**

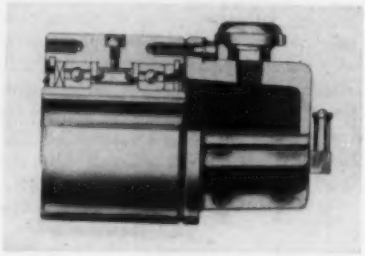
Circle 306 on Reader Service Card



Compressed air line lubricator

has transparent dome that allows user to see changing oil delivery rate as it is manually adjusted. Unit is available in $\frac{1}{4}$-, $\frac{3}{8}$-, $\frac{1}{2}$-, $\frac{3}{4}$- and 1-in. pipe sizes for service to 150 psi. Provides constant oil delivery in applications that move as little as 1 to 2 cu ft of air per min. Only a 0.4-lb pressure drop is needed to start oil feed. Inlet and outlet ports are interchangeable to simplify installation. To install: Place lubricator with fill plug in most convenient position, rotate dome 180° and replace it on lubricator body so that arrow points in direction of flow. Bowl can be filled through large opening in top of body without shutting down production air supply. **Hannifin Co, Dept 126, 501 S Wolf Rd, Des Plaines, Ill.**

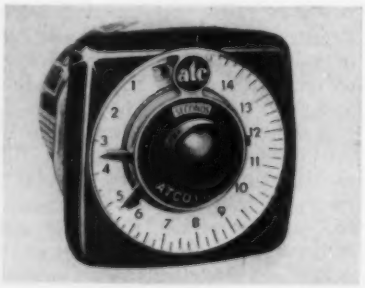
Circle 307 on Reader Service Card



Hi-speed backstop clutches . . .

have torque capacities of from 140 to 1900 lb-ft, bore diameters from 0.500 to 2.750 in., and provide max overrunning speeds on inner races from 1800 to 3000 rpm. Designed for mounting on low-speed or high-speed shafts of gear reducers used for driving conveyors and bucket elevators. Incorporate neoprene seals to withstand high speed and heat and also are equipped with integral, finned oil reservoir and sight gage to minimize frequency of lubrication. Special sprags (chromium and high-carbon steel are alloyed to produce a sprag surface with a hardness similar to tungsten carbide) resist wear, abrasion and corrosion. **Formsprag Co, 23601 Hoover Rd, Warren, Mich.**

Circle 308 on Reader Service Card



Reset dial timer . . .

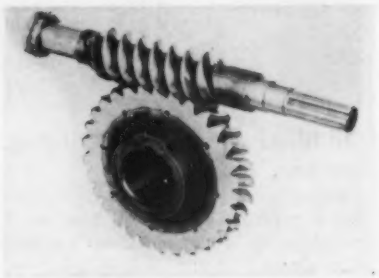
is a synchronous motor-driven unit for control of ac or dc loads within variable timed sequences or intervals. Handles up to seven individual load circuits, with all load connections internally wired independently to a 14-point terminal block. Incorporates gear train which permits gears to rotate in one direction only. Available in 16 dial ranges, from 6 sec to 60 hr full range. **Automatic Timing & Controls Inc, King of Prussia, Penna.**

Circle 309 on Reader Service Card

Hi-temp adhesive . . .

is a two-component adhesive consisting of an epoxy paste and a powdered curing agent that maintains its adhesive strength to temps over 400 F when cured at room temp (most room temp-cure epoxy adhesives soften at 165 to 200 F). Also withstands short exposures to 500 F and will maintain adhesive properties in excess of 200 hr at 400 F. Has pot life of 15 min. at room temp and cures in thin glue lines in 24 hr, though several days to a week are required for max adhesive strength. **Epoxylite Corp, 1428 N Tyler, South El Monte, Calif.**

Circle 310 on Reader Service Card



20° pressure angle gears . . .

in pitches from 3 to 20, are from stock at prices competitive with $14\frac{1}{2}$° gears. They are designed to be interchangeable, in sets, with $14\frac{1}{2}$° gears, offering higher hp ratings and greater tooth bearing areas which provide greater radius of engagement. Types available include spur, bevel, miter sets (both straight and spiral); helical and worm and gear sets. Materials used include high-carbon steel, alloy cast iron, and nickel bronze (worm gears). Non-metallic spur gears are offered for low-load, high speed applications. **Morse Chain Co, Ithaca, NY.**

Circle 311 on Reader Service Card

Thermocouple material . . .

is matched to material in test vehicle wall, making possible more accurate surface or in-wall temperature measurements. Matching of materials is said to eliminate errors caused by differences in thermal properties at point of measurement. Thermocouples have been fabricated from plexiglass, Teflon, asbestos phenolic, micarta, graphite, copper, molybdenum and tungsten, but any machinable plastic, nonmetallic or metallic material can be used. Thermal elements are composed of flat ribbon wires, insulated by thin sheets of mica (only nonmatching materials in thermocouple). These components then are "sandwiched" between a split tapered pin and pressed into the thermocouple housing. Unit has repsonse time of less than 10 millionth of a sec to transient

continued on page 54

richard latham: "second generation" designer

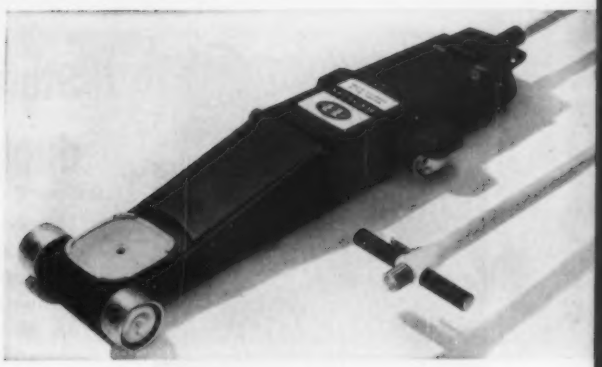
latham talks design

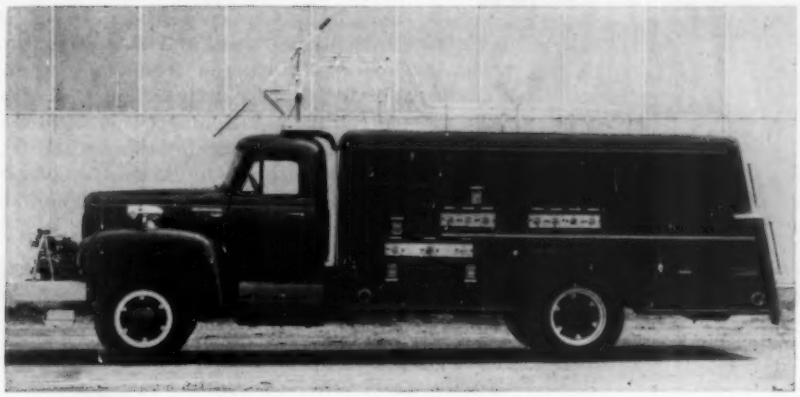
When you think of industrial design, you tend to recall the giants that gave birth to the profession in the late Twenties: Loewy, Teague, and Dreyfuss. But hot on their heels is another generation of designers. One of them is this year's Chairman of the Board of the American Society of Industrial Designers, Richard Latham, a man who as late as 1940 was a combination floor sweeper and designer at Montgomery Ward when it was one of only three Midwestern companies that had design departments.

Those were the days when industry was just beginning to realize that good design represented a competitive advantage. They were the days of Montgomery Ward's "Good–Better–Best" policy in which they used design subtleties to distinguish between three different grades of the same item. "In those days," Latham says, "design was largely a matter of face lifting. Today, industrial design is becoming a true planning function for industry, and the designer is concerned as much with making a product work better as he is with appearance."

Latham is well-qualified to tackle any problem of form or function. During World War II he worked in engineering research and development on aircraft, including the jet fighter, weapons systems and ballistics, and the first air-borne radar system. After the war he devoted five years abroad to the German porcelain industry. Since then his work has centered on "hard" products and transportation. Included in the latter are work on the new Greyhound Bus and the DC-6 and DC-7 aircraft series. Since early 1955, he has headed his own industrial design firm of *Latham, Tyler, Jensen* and worked on ceramic consumer products, corporate identity programs, the design and marketing of housewares, retail shop layouts, aircraft instrumentation and design of medical equipment. A number of striking exhibits have been designed by *Latham, Tyler, Jensen,* including the Cantigny War Memorial Museum at Wheaton, Illinois, and they're currently working on the Hall of Health for the California Museum of Science and Industry.

What is the designer's function today? "The real question," Latham says, "is what *should* it be? Industry is using industrial designers to create or redesign products for next year's markets, or at the most just a few years ahead. But the industrial designer's real talent lies in genuine innovation, in crystallizing the reality of not only what a product might be, but what it *can* be. He conceives of totally new products that aren't even





in existence today, and then gets down to the hard work of adapting them to the home, to the everyday business of living. The true industrial designer works years ahead. He dreams. Short-term design and redesign on the other hand, should be a staff function of industrial corporations where it can be integrated into the total marketing plan, including product development, sales, market development, merchandising. Then the true industrial designer can act as a pure consultant to industrial management." Is he needed? "Woefully. He's the only artist in business."

"But let's not confuse the artistic designer with the Left Bank," Latham says. "Industrial designers are—and have to be—hard-headed businessmen who must know what will sell and how well and easily the product can be manufactured. I haunt machine shops and production lines," Latham says. "I talk to workers and foremen and try to analyze production problems, as well as educate them about what we're striving for in the product design. Just as unrealistic design can make the production man lose his hair, a lack of understanding on the part of production people and insistence on long-standing production techniques can often ruin a design."

Selection of the right material for a design is another Latham trademark. The material must be capable of convenient fabrication, it must express the personality of the product that the designer is trying to achieve, and it must help move the product off shelves and showroom floors.

Latham has used dozens of different materials, and it is no coincidence that the majority of his firm's product designs have used steel in one way or another. He says, "Steel, after all, was the first metal available to man that could be stretched and pulled into form. Steel, to the designer, is form in tension. It has an inner strength that you feel. It was the first material that had enough ductility to be formed and drawn, yet at the same time enough strength to make a skeleton from which things could be hung, such as auto frames and certain types of architectural systems. And let's not overlook the fact," Latham says, "that this modern metal is the same one that made mass production possible."

The moral? Steel in its many forms has been with us for years, yet it continues to excite the imagination of people like Dick Latham and his associates who make a business of designing for the future.

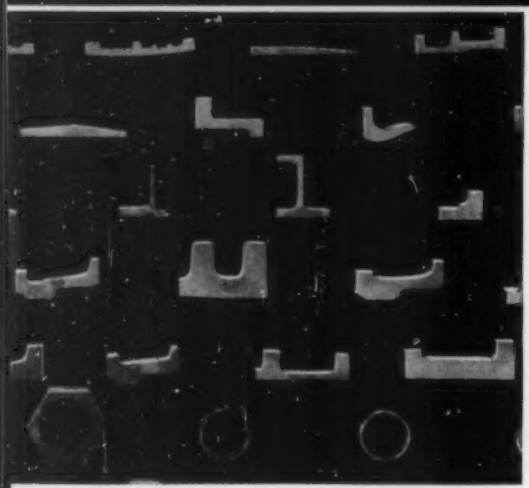
USS United States Steel

TRADEMARK

Stainless Steel heat exchangers duplicate outer space at −443°F

Missile scientists have turned to Stainless Steel to duplicate atmospheric conditions in outer space and save the great expense of actually firing missiles for pure test purposes. They can create temperatures as low as −443°F in Stainless Steel heat exchangers—and reduce air pressure to one-billionth of an atmosphere. Here is the problem Stainless solved: high-velocity-gas research demanded a heat exchanger that combined rapid cooling, compactness, lightness and freedom from contamination. For Tranter Manufacturing Company, fabricators of the unusual heat exchanger shown in the picture, Stainless filled the bill. Their Stainless "Platecoil" heat transfer unit cools 50% faster than conventional coiled pipe designs; it weighs half as much as conventional units, and occupies only one-half the space. Because of Stainless Steel's superior corrosion resistance, problems of corrosive scaling are eliminated. Pipe design is unusual. Two sheets of Stainless are embossed with serpentine half-channels, then welded together. Stainless "Platecoil" is used to jacket the launching tubes on the Polaris submarine, and has many more conventional uses in the chemical, food processing and petroleum industries. No other metal could do the job as well as Stainless Steel.

USS Design Steels:



Cut costs with USS Special Sections

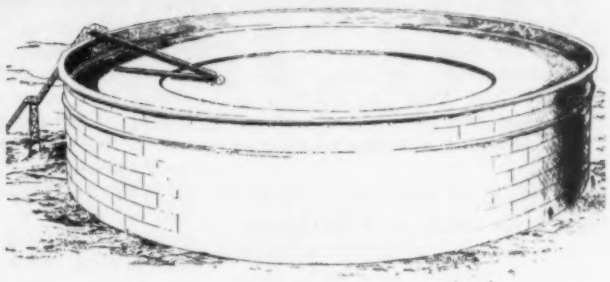
A USS hot-rolled special section is an irregular steel shape, designed specifically for one purpose and rolled so that there is little or no finishing required to meet final specifications. It is difficult to predict *where* a special section can come into a design. Its adoption follows a detailed analysis of production operations, such as machining, grinding, welding or riveting; a study of scrap losses, freight economies, and a close look at mechanical requirements. Take a close look at some of the parts now being used in your designs. If you come to a conclusion that money can be saved or reliability can be improved, get in touch with us. If you want to see how manufacturers have made good use of USS Special Sections, write for our booklet, "Hot-Rolled Carbon Steel Special Sections."

This mark tells you a product is made of modern, dependable Steel.

600,000-barrel capacity storage tank built of USS "T-1" Steel

The world's largest oil storage tank is located in Mena Abdulla, Kuwait, on the Arabian Gulf. It was built by the Chicago Bridge & Iron Company of high-yield-strength USS "T-1" Constructional Alloy Steel. Its contents can fill a new super-tanker in one stop instead of several. By using "T-1" Steel, the contractor was able to save fabricating, shipping and erecting costs and get *extra* strength and corrosion resistance.

The tank is 64 feet high and 260 feet in diameter. The shell consists of six 8-foot rings of "T-1" Steel, made to 115,000 psi minimum ultimate strength, and two top 8-foot rings made of A 131 grade A carbon steel. The tank has a Horton pontoon floating roof and the bottom of the vessel was made of A 283 grade C plates ¼-inch thick. The "T-1" Steel shell thicknesses, which ranged from one inch down to ½-inch, were determined on the basis of a design stress of 38,333 psi, ⅓ of the minimum ultimate strength of the steel. Joint efficiency: 100%. By using USS "T-1" Steel in the lower rings, *42% less steel* was required.



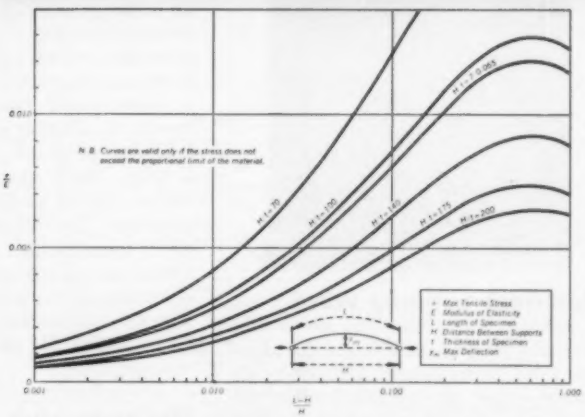
USS "T-1" Steel offers the designer exceptional strength and toughness, even at very low temperatures. Some suggested uses are pressure vessels, equipment-hauling trailers, LP gas transports, offshore rigs and other equipment that must be strong, light and corrosion-resistant. Our booklet, "USS 'T-1' Steel," tells the whole story. Write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

"HORTON" is a registered trademark of Chicago Bridge & Iron Company

new solutions for new problems

U.S. Steel offers information on stress corrosion

U. S. Steel researchers have been carrying on a program to determine the suitability of several very high strength alloy and stainless steels for aircraft and missile applications. Pictured here are several steel bands that have been tested to failure as part of this program. The study includes the effects of heat treatment and coatings on stress corrosion, and discusses the microstructural characteristics of stress corrosion cracks. The study is called, "Stress Corrosion of Steels for Aircraft and Missiles." Get your copy by writing to United States Steel. USS and "T-1" are registered trademarks of United States Steel.



For the literature offered here, or for additional information, write to United States Steel, Room 6358, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS United States Steel

flow, a temp range from —320 to over 5000 F and an operating pressure range of 3000 psi and above. Sensing tip is reusable, and thermal junction is continuously maintained even during erosion. **Nanmac Corp, Dept 11, PO Box 8, Indian Head, Md.**

Circle 312 on Reader Service Card

Hydraulic seals and packings

made of urethane elastomer, have tensile strength of over 5000 psi at break, which enables them to withstand pressures of 3000 to 10,000 psi and higher with no backup rings. Chamfered sealing lip on seals allows leakproof sealing even at very low pressures and simple assembly of seal bearing components into the housing without special tools or fixtures. Both seals and packings operate over temp range from —40 to 225 F, are compatible with most hydraulic fluids and offer high abrasion- tear- and wear-resistance. Though hardness of material used is 90 Shore A durometer, it is said to have high resilience—550% elongation at break. Most sizes, available as U-cups, O-rings, cup packings, flange packings, rod wipers and washers, are from stock. **Disogrin Industries, Div of Pellon Corp, 510 S Fulton Ave, Mt Vernon, NY.**

Circle 313 on Reader Service Card

Motorized butterfly valve . . .

is self-contained, 2-position air control valve with integral sealed motor that operates valve shaft directly, eliminating all linkages. High and low flow positions are set by movement of limit switches. Valve motor requires 110 v, single-phase, 60-c power and draws 20 w. It develops torque of 40 lb-in. Unit can be installed in any position and is available in 1- through 6-in. pipe sizes. Suitable for low pressure process and combustion air applications at pressures up to 5 psi. **North American Mfg Co, 4455 E 71st St, Cleveland 5.**

Circle 314 on Reader Service Card

Expansion insert . . .

installed after molding, provides a large bearing surface for electrical connectors and a hold-down feature for mating parts in molded plastic. This is achieved by a wide flange flush with upper end of insert's body. When permanently attaching mating parts, insert is placed through a hole in one part and into a cored or drilled hole in the parent material. An integral eared spreader then is depressed, forcing the knurled outer portion of the insert into the wall of the hole in the parent material. The flange permanently joins the two parts. Additional members can be joined with a binding head screw installed in the internally threaded portion of the insert. Insert is said to be suitable for thin section applications since the downward installation force is absorbed by the flange. Properly installed, a 6-32 insert withstands 18 in.-lb torque and 240 lb direct pull-out. Available in screw sizes 4-40 through ¼-20. **Phelps Mfg Div, Heli-Coil Corp, Danbury, Conn.**

Circle 315 on Reader Service Card

Single-purpose solenoid . . .

designed for hydraulic and pneumatic valve applications, is available in four sizes with push range of 2 to 12 lb with up to a ½-in. stroke. Furnished with or without a captive or loose push pin of various lengths and diameters and with either a standard bobbin or epoxy model core. **National Acme Co, Electrical Controls Div, 170 E 131st St, Cleveland 8.**

Circle 316 on Reader Service Card

Transistor ac voltmeters . . .

include two single range models, identical except for size of their indicating meters—3½ in. for one and 2½ in. for other. When mounted on instrument panels, both instruments take up only room required for their indicating meters and extend only 6½ in. behind panel. Both are completely self contained, including power supply, and are housed in aluminum cylinders. Have signal isolation which allows for measurements independent of panel and power ground potential. Thermal resistors are said to assure operation from —67 to 131 F, while changes in line voltage amounting to 20% reportedly do not cause accuracy derating. **Trio Laboratories Inc, Plainview, LI, NY.**

Circle 317 on Reader Service Card

Miniature pitch chain . . .

and sprockets are from stock. The 0.1475 pitch chain is supplied in type 18-8, nonmagnetic, stainless steel in lengths from 5.900 to 57.525 in. (special lengths on request). Said to eliminate slippage, noise and excess backlash and to offer high reduction capabilities with extremely low torque factor. Pin type hub sprockets are available in ⅛-, $\frac{5}{16}$- and ¼-in. shaft sizes, while hubless sprockets come in ⅜-in. bore size. Supplied in stainless steel, aluminum, linen phenolic or nylon. **PIC Design Corp, 477 Atlantic Ave, East Rockaway, LI, NY.**

Circle 318 on Reader Service Card

Hydraulic pumping system . . .

is a 5-gal. unit for use in existing or OEM equipment where compactness is required. Unit measures only 8 x 18 x 16 ft. Comprises a tank with an external, horizontally mounted ½- or ¾-hp, totally enclosed ball bearing motor directly coupled to a positive displacement gear pump which delivers up to 1½ gpm. Also includes 0 to 250-psi relief valve and a replaceable 5-micron cartridge filter. Suitable for 150- to 200-ssu hydraulic oil. All outlets are manifolded. **Bartsch Tool Corp, 3714 Oakton St, Skokie, Ill.**

Circle 319 on Reader Service Card

Tubular heaters . . .

are electrically powered elements available in straight-line and finned models. Range in length from 6 in. to 45 ft without joints or welds. Power consumption is 500 w for an oil immersion model to 10,000 w and up for a complex finned version. Straight-line heaters are suitable for water and oil immersion heating, contact heating of metals and circulating liquid heating. Finned models are for unit ventilators, duct work, heat pumps, forced air systems and electrified railroad car heating. From stock. **Heatrex Inc, Dept 564 Meadville, Penna.**

Circle 320 on Reader Service Card

Panel meters . . .

are 0-50 milliamp dc meters which combine an anti-parallax mirrored scale, perfect tracking over entire scale and accuracies of 1% or better. Have spring-mounted jewel bearings, mirror-polished steel pivots and machine-turned parts. Pointer types include knife edge, lance and combinations. All meter types are available with sensitivities of 10,000 or 20,000 ohm per v or intermediate values. Delivery in 1 wk. **Airpax Electronics Inc, Seminole Div, Fort Lauderdale, Fla.**

Circle 321 on Reader Service Card

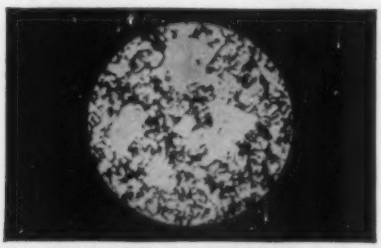
continued on page 56

Linde Coatings & materials News

LINDE COMPANY, DIVISION OF UNION CARBIDE CORPORATION

Abrasives, 99.98% pure alumina, simplify polishing of metals

Once it was a complex art to put precision finishes on metals. Polishing, sharpening, honing involved many abrasives and techniques. Now, with LINDE *alumina* abrasives, metallographic polishing is routine.

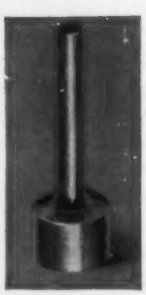


Magnified 1500 X—a sample of tungsten carbide with 6% cobalt binder polished by modified procedure for hard materials. (Murakami's etch).

In three grades LINDE 0.3 A (alpha alumina), LINDE 0.05 B (gamma alumina), and LINDE 1.0 C (alpha alumina)—these low-cost, fast-cutting white powders can be used with many materials. LINDE 1.0 C removes material rapidly; LINDE 0.3 A cuts quickly, yet leaves a clear, unsmeared finish; LINDE 0.05 B cuts slower but produces a finer finish. Uniformity of the particle size eliminates levigation in finishing.

Powders can be used dry, or mixed with water or other vehicles to make a thin slurry or heavy paste, or compounded with waxes in convenient stick form. Both are highly resistant to common acids. Check, send the coupon.

Now—high workability for tungsten in crystal form



Ingots of LINDE crystal tungsten can be worked into intricate shapes for electronic, other applications. It can be done at room temperature, using standard machine tools. Metal has no porosity, relatively low impurity, is less brittle than PM tungsten. Crystal tungsten also has unusual ductility, has been drawn into wire as fine as 1 mil for greater yield of finished product from starting ingot. Check, send the coupon for details.

High-grade wear from lower-grade metals —with tungsten carbide coatings

Bearings on the torque meter shaft of a turbo-prop aircraft engine gave only 50 hours operating life, even though the bearings were heat-treated. The short life was caused by severe fretting corrosion. Then the bearing surfaces were given a tungsten carbide coating with LINDE's Flame-Plating process. Service life is now greater than 1500 hours.

A critical tolerance had to be maintained between a ball piston and the piston wall in a hydraulic pump. Carbide inserts mating with steel balls proved unsatisfactory due to differential expansion at operating temperature. Carbide balls added considerable weight. The problem was solved with Flame-Plated steel bushings which had the correct expansion rate and a wear resistance equal to solid carbide—at considerably less weight.

Aluminum toughened

In another situation, aluminum rocker arms were being used in an aircraft heater mechanism to keep weight under overall requirements. But, because of severe sliding abrasion, the relatively soft metal lasted only about 100 hours. When the wearing surface was given a precision coating of tungsten carbide, service life jumped to more than 1000 hours. And the desirable light weight of aluminum was not lost.

These are typical examples of how LINDE's custom-coating service can be used to upgrade many ordinary metal parts by coating their wearing surfaces with tungsten carbide, aluminum oxide, tungsten, molybdenum, other oxides and materials. The thin coatings multiply wear performance many times over—but at the lower costs and with the retention of the other desirable properties associated with the base metals.

If you need technical information on particular problems with wear caused by abrasion, corrosion, erosion—even under conditions of severely high temperature, high load, or absence of lubricant or cooling—LINDE can help you. Check and send the coupon below.

PHYSICAL DATA—FLAME-PLATED COATINGS

COATING DESIGNATION	LW-1	LW-1N	LW-5	LC-1A	LA-2
Approx. Composition by weight	Tungsten Carbide + 6% to 8% Co	Tungsten Carbide + 13% to 16% Co	25% WC + 7% Ni + mixed W-Cr Carbides	85% Cr_3C_2 + 15% Ni-Cr	99% + Al_2O_3 (gamma)
Hardness Vicker's (VPN_{300})	1200 to 1450	1050 to 1150 VPN 70 to 71 R_c	1000 to 1200 VPN	850 VPN	1000 to 1200 VPN
Maximum temp. in oxidizing atmosphere	1000°F.	1000°F.	1400°F.	1800°F.	1200°F. to 1800°F.
Coefficient of thermal expansion	4.0 x 10 °/°F. Avg. 70 to 1000°F.	4.7 x 10 °/°F. Avg. 70 to 1000°F.	4.6 x 10 °/°F. Avg. 70 to 1400°F.	6.4 x 10 °/°F. Avg. 70 to 1800°F.	3.9 x 10 °/°F. Avg. 70 to 1832°F.
Modulus of Rupture	67,000 psi	80,000 to 106,000 psi	40,000 psi	75,000 psi	22,000 psi
Modulus of Elasticity	44 x 10^6 psi	42 to 40 x 10^6 psi	17 x 10^6 psi	22 x 10^6 psi	16 x 10^6 psi
Porosity	0.5%	0.5 to 1.0%	0.5%	0.5%	1.0%
Specific Gravity	14.2	13.2	10.1	6.54	3.45
Specific Heat	0.048	0.056	0.070	0.127	0.196
Thermal Conductivity	5.3 at 500°F.	5.3 at 500°F.	3.8 at 500°F.	4.3 at 500°F.	0.86 at 500°F.
Main features	Extreme wear resistance	Excellent wear resistance + increased resist. to mechanical and thermal shock.	Excellent wear resist. to higher temps. Improved corrosion resist.	Good wear resist. at high temp. or in corrosive media. Resists flame impingement.	Excellent resist. to wear, chem. attack and high temperature deterioration.

CHECK—CLIP COUPON—ATTACH TO BUSINESS LETTERHEAD

Linde Company, Dept. PG-75
270 Park Avenue
New York 17, N.Y.

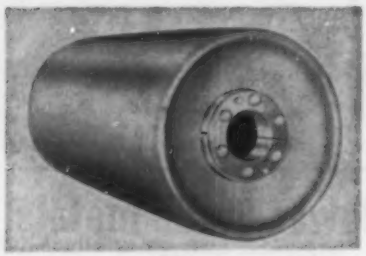
Please send details on the items checked:

- ☐ LINDE Flame-Plated Coatings
- ☐ LINDE Alumina Abrasives
- ☐ LINDE Arc Crystal Tungsten

UNION CARBIDE

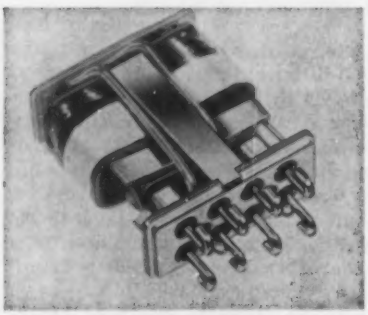
LINDE COMPANY

"Linde" and "Union Carbide" are registered trademarks of Union Carbide Corporation



One-piece steel pulley . . .
has spun end construction with no end plate weldments. This is said to eliminate principal sources of metal fatigue, stress and other problems. Available up to 24 in. dia. **Stephens-Adamson Mfg Co, Aurora, Ill.**

Circle 322 on Reader Service Card



Magnetic latching relay . . .
is 10-terminal unit that can be installed without regard to polarity. Contacts enable use from dry circuit to nominal 10-amp resistive loads at 28 v dc or 110 v ac, 400 cps. Responding to a 10-millisec square wave or capacitor discharge pulse, unit requires only 12 millisec max for operation or 2 millisec max for transfer. For operation in deleterious atmospheres, unit is hermetically sealed and check to helium leakage rate of 10^{-8} cc per sec. Measures 0.515 x 1.075 x 1.3 in. and is priced at approx $27. Delivery in 3 to 4 wk. **Babcock Relays, Div of Babcock Electronics Corp, 1645 Babcock Ave, Costa Mesa, Calif.**

Circle 323 on Reader Service Card

Transistorized strain indicator . . .
operates from self-contained batteries or external ac supply. Using integral controls, it is possible to balance measurement bridge, after which strain is read directly from instrument. Multi-point and long-term strain measurements also are possible. Separate output connections are used for display on an oscilloscope, oscillograph or pen-type recorder. Linear-calibrated null meter permits direct measurement of extremely low values of strain. **Metrix Inc, PO Box 683, Walnut Creek, Calif.**

Circle 324 on Reader Service Card

DESIGN LITERATURE

Fatigue Testing and Analysis of Results

W WEIBULL. Pergamon Press Inc, 122 E 55 St, NY 22. 6¼ x 10, 305 pp. $12.00.

This book, while having special interest for the aircraft industry, will also be of great value to all engineers and research workers who are concerned with fatigue in metals and metal structures. After an introductory chapter discussing symbols and nomenclature, the book discusess fatigue testing machines and equipment, followed by chapters covering instruments and measuring devices, the design, preparation, measurement and protection of test pieces, factors affecting test results, planning of test programs, presentation and analysis of results.

Transformers

ALEXANDER SCHURE, John F. Rider Publisher, Inc, 116 W 14 St, N.Y. 5½ x 8½, 88 pp. $2.00.

A simplified but complete discussion of the magnetic principles underlying the operation of the transformer, with chapters on transformer design and construction. Typical transformers are: power transformers, audio, high-frequency, autotransformer, instrument, saturable reactors, and balancing transformers.

Dynamic Analysis of Machines

JOSEPH E SHIGLEY. McGraw-Hill Book Co, Inc, 330 W 42 St, New York 36. 6¼ x 9¼, 645 pp. $7.50.

This book is a companion volume to Professor Shigley's KINEMATIC ANALYSIS OF MECHANISMS, published in 1959. These two books are available separately and in a combined volume titled THEORY OF MACHINES.

A strong feature of the book is its use of the unit vector approach from the beginning to determine the static and dynamic forces in machinery. This method is of value for analyzing static forces and static bearing reactions in gear trains composed of spur, helical, bevel, and worm gears. It is also used for the dynamic analysis of linkages, including space mechanisms, and to introduce momentum concepts.

Mechanical vibrations are introduced through expanded coverage early in the text to fully develop the subject matter of dynamic analysis. Transients are treated thoroughly by the analytical method and also by the graphical phase-plane method. The phase-plane method is developed with unusual clarity and used very simply to solve many otherwise difficult problems. The usual material on the vibration of beams and shafts and Holzer's method are included.

Other features of this text include the chapter on cam dynamics and the highly-requested chapter on feedback control systems for mechanical engineers.

ABSTRACTS FROM THE LITERATURE

Reliability Testing

Easy-to-use 'break-even' charts help management predict the economic impact of adding equipment and personnel, of cutting prices or increasing costs, and of changing service or product mix. They can guide marginal pricing policies and generally point up the quality of decisions that result in success or failure in the competitive environment.

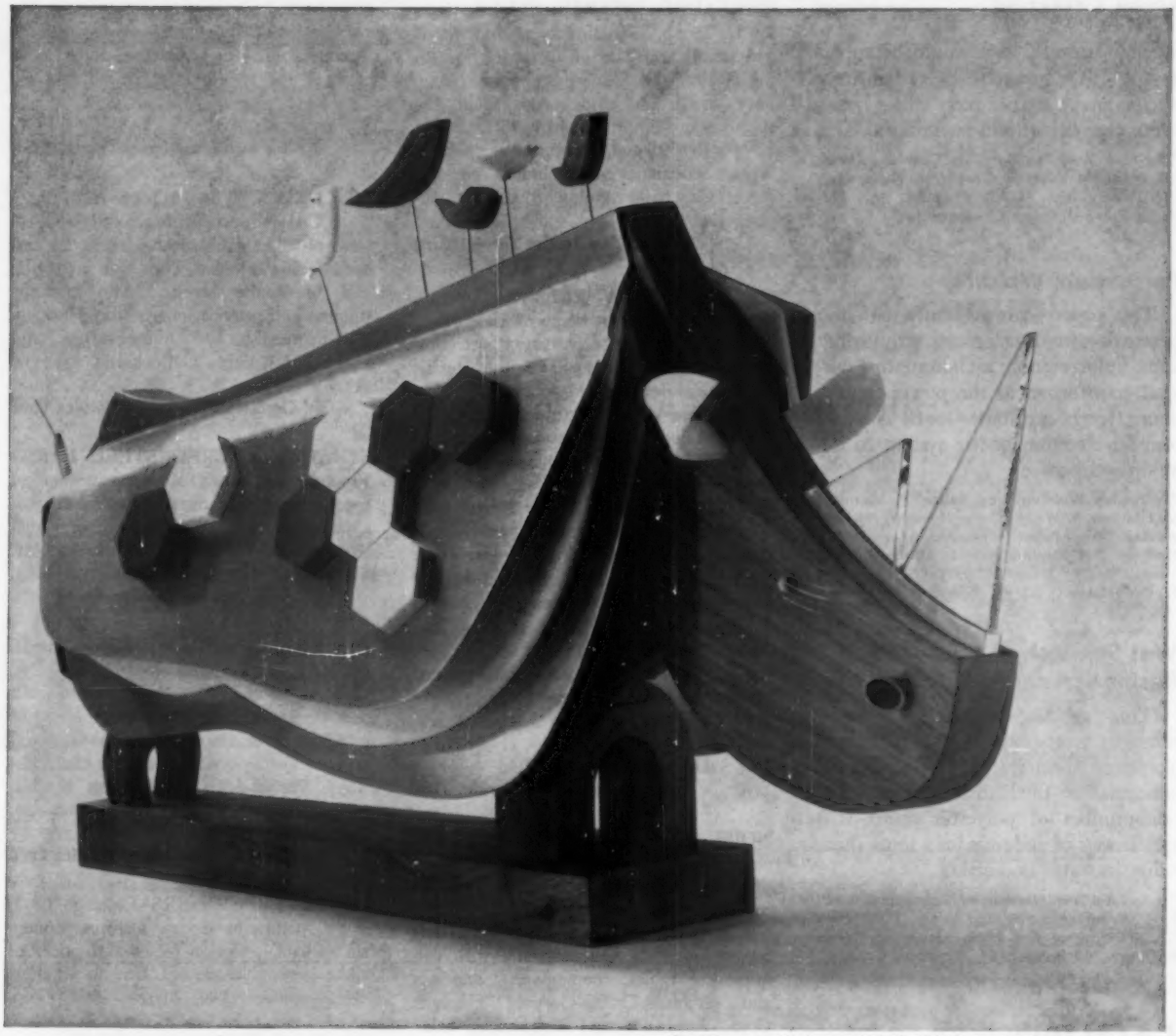
"Reliability Testing for Managerial Decisions," by Spencer A. Tucker, Partner, Martin & Tucker, Engineers, Little Neck, NY. "Environmental Quarterly," Oct. 1960, 252-46 Leeds Road, Little Neck 62, NY.

The New A-48 Test Bar

The most commonly used ASTM specification for gray iron, A-48, has been recently revised. The new version, A-48-60T, has several new and vital requirements.

Since the transverse test is no longer recognized in this specification, it is not necessary to cast a long test bar. Although the old test bar sizes can still be officially used, it is now required that all bars be poured on end in dry sand holes. Some foundries plan to continue using the long test bars because they use the transverse test for quality control and sell most of their castings to other specifications. In foundries where A-48 is the principal specification, a number of tensile tests will probably be required every day

continued on page 58



Sculpture created especially for 3M Company by Guy Palazzola

STRENGTH

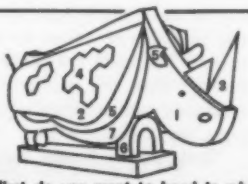
. . . Bonds "strong as a bull rhinoceros" made with SCOTCH-WELD® Brand Structural Adhesives

Whatever materials you're bonding (to the same or to another material), a SCOTCH-WELD Brand Structural Adhesive bond will give you a bonus of structural strength at the joint, with the flexibility to resist vibrational fatigue. SCOTCH-WELD adhesive bonds distribute stress loads uniformly, and protect the strength and integrity of the materials by eliminating fastening holes, maintaining the finish, and sealing joints against corrosion.

Fatigue tests show that metal-to-metal joints in Convair's 880 jet transports and Air Force F-102A jet interceptors, bonded with SCOTCH-WELD adhesives, will outlast the metal structure they bond together! In industry, too, SCOTCH-WELD adhesives are finding use in joining hermetically sealed metal shipping containers, multiple piece castings and thinner gauge metals, where tear strength would limit the effectiveness of other joining methods.

Look first to 3M! A pioneer in adhesive research, 3M has developed the widest line of adhesives in the industry. These Technical Service facilities are at your disposal. For an accurate appraisal of how an adhesive can add strength, light weight, production economy, and greater design freedom to your process or product, call your nearest 3M Field Engineer or write to: AC&S Division, 3M Company, Department SBS-71, St. Paul 6, Minnesota.

"SCOTCH-WELD" is a Reg. T.M. of 3M Co. © 3M Co., 1961.



What do you want to bond to what?
The 3M Rhino is fabricated of these materials and bonded with SCOTCH-WELD Brand Structural Adhesives:
1. Wood 2. Aluminum 3. Glass 4. Ceramic
5. Plastic 6. Permanent Magnet 7. Brass

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

so the transverse test would be superfluous. A short test bar is entirely adequate for tensile tests while being more convenient and economical.

"The New A-48 Test Bar," by Charles F. Walton, technical director, Gray Iron News, Aug 1960. Gray Iron Founders' Society Inc, National City-E 6 Bldg., Cleveland 14.

Percussion Welding

This paper deals primarily with the percussion-welding process employing: Low voltage from an alternating-current transformer as the power supply, some type of arc starter—such as a nib, and an electromagnetic system to develop weld force.

"Percussion Welding," by Robert F. Manning, and Jerome B. Welch, Cutler-Hammer, Inc, Milwaukee, Wis. Paper presented at the AWS National Fall Meeting held in Pittsburgh, Sep 1960. Welding Journal, Sept. 1960, American Welding Society, 33 W. 39th St., NY 18.

Wet Strength of Polyester Resins

This article evaluates the wet-strength retention of glass-reinforced polyester laminates. Of particular significance is the indication that the acid-number of polyester resins is a quick way of judging long-term durability in water immersion.

"Long-Term Wet Strength of Polyester Resins," by C. E. Lootel and H. E. Fordyce, The Marley Co, SPE Journal, Oct 1960, Society of Plastics Engineers, 65 Prospect St, Stamford, Conn.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 61.

SELF-SEALING COUPLINGS—Bulletin 629, 20 pp. Reviews common uses of couplings in fluid piping systems, such as replacing two shutoff valves to maintain pressure in a hydraulic system or prevent fluid drainage from the system. Drawings show available types and their applications. Aeroquip Corp, Jackson, Mich.

Circle 350 on Reader Service Card

HIGH-PRESSURE SEALS, FASTENERS—Catalog 359B, 16 pp. Covers explosion- and high-pressure seals for switches and shafts, high-pressure self-sealing fasteners, transparent and flexible switch seals, auto-deflecting grounding blades, etc., providing diagrams and specifications for each. APM Corp, 41 Honeck St, Englewood, NJ.

Circle 351 on Reader Service Card

THREADED INSERTS, STUDS—Catalog D, 28 pp. Contains insert dimensions and installation data on 20 series, including lightweight, heavy-duty, extra heavy-duty inserts and studs. Also spells out specifications equivalent to NAS Drawings 1394 and 1395 and advantages of different types. Schematics are included. Newton Insert Co, 6500 Avalon Blvd, Los Angeles 3.

Circle 352 on Reader Service Card

CASTERS AND WHEELS—Catalog 150, 48 pp. Offers tabulated specifications, data on caster and wheel construction, selection factors, mounting arrangements, materials and accessories. Illustrations include exploded view diagram, cutaways, cross-sections and detailed line drawings. Hamilton Caster & Mfg Co, 1700 Dixie Hwy, Hamilton, Ohio.

Circle 353 on Reader Service Card

BALL VALVES—Catalog, 16 pp. Contains specifications and characteristics of complete line, including top entry flanged valves, screwed end bar stock units and vacuum to 3000 psi shutoff units. Supplies cutaway drawings, phantom and exploded views, materials of construction charts, pressure-temperature curves and dimension tables and drawings. Hydromatics Inc, 5 Lawrence St, Bloomfield, NJ.

Circle 354 on Reader Service Card

NOISE CONTROL MATERIALS—Brochure 1-EA-910-A, 14 pp. Outlines approaches to solving acoustical problems in appliances and equipment. Details test methods used to arrive at basic data on max quieting and illustrates with performance tables, nomograph, drawings and photos. Owens-Corning Fiberglas Corp, Appliance and Equipment Sales, Toledo 1, Ohio.

Circle 355 on Reader Service Card

CIRCUIT BREAKERS—Pocket-size booklet, 32 pp. Cites advantages of circuit breakers over safety switches, including reduced cost, space and maintenance. Price and size comparisons are charted. Westinghouse Electric Corp, Standard Control Div, Beaver, Penna.

Circle 356 on Reader Service Card

METAL FINISHING—Brochure, 4 pp. Summarizes characteristics of materials and compounds for such finishing operations as buffing, burring, polishing and satin finishing. Also covers additives and specialties for plating gold, silver, copper, nickel, cadmium, brass and zinc. Lea Mfg Co, 16 Cherry Ave, Waterbury 20, Conn.

Circle 357 on Reader Service Card

SELENIUM PHOTOVOLTAIC CELLS—Bulletin 03-201-A, 6 pp. Data supplied ranges from explanations of current input and spectral response to dimensional diagrams. Series of curves show output vs illumination, voltage vs current, exposure effect-fatigue and temperature effect. Daystrom Inc, Weston Instruments Div, 614 Frelinghuysen Ave, Newark 12, NJ.

Circle 358 on Reader Service Card

MOLDED CUPS—Brochure AD-189, 4 pp. Carries specifications and applications of rubber, rubber and fabric, leather, and Teflon molded cups for hydraulic and pneumatic service. Also contains photos and service charts for fabric-inserted, metal-backed, homogeneous, and pump piston cups. Garlock Inc, Palmyra, NY.

Circle 359 on Reader Service Card

STRAIN-TEMPERED STEEL BARS—Brochure, 4 pp. Tabulates mechanical specifications and discusses strength, machinability and applications of high strength, cold finished steel bars. SAE Steels Inc, 1420 E 47th St, Cleveland.

Circle 360 on Reader Service Card

SELENIUM RECTIFIERS — Bulletin 400, 4 pp. Supplies electrical and mechanical specifications of selenium cells and stacks and cartridge type selenium rectifiers. Includes cutaway drawings and curves showing typical operating characteristics. Vapor deposition process is illustrated. Semiconductor Div, Syntron Co, Homer City, Penna.

Circle 361 on Reader Service Card

DRIVE TENSIONERS—Catalog TR-1, 4 pp. Contains design features, dimensional data, selection tables and prices of three types that are effective on all drive types. Service Div, Maurey Mfg Corp, 2907 S Wabash Ave, Chicago 16.

Circle 362 on Reader Service Card

SPACERS AND POSTS — Catalog SPPM-1, 4 pp. Tabulates dimensions and prices of over 125 metallic standoff types. Also supplies material and finish specifications. Angler Industries Inc, Metuchen, NJ.

Circle 363 on Reader Service Card

TESTING MACHINES—Reference manual, 8 pp. Alphabetically lists 1239 pyhsical testing machines for all industries obtainable from one source. Testing Machines Inc, 72 Jericho Turnpike, Mineola, NY.

Circle 364 on Reader Service Card

SINGLE-CIRCUIT SHALLOW CONTACT BLOCKS—Bulletin GEA-7320, 2 pp. Discusses performance and gives ratings of units for use with heavy-duty, oiltight pushbutton operators. Seven of 44 possible circuit combinations are pictured. General Electric Co, Schenectady 5, NY.

Circle 365 on Reader Service Card

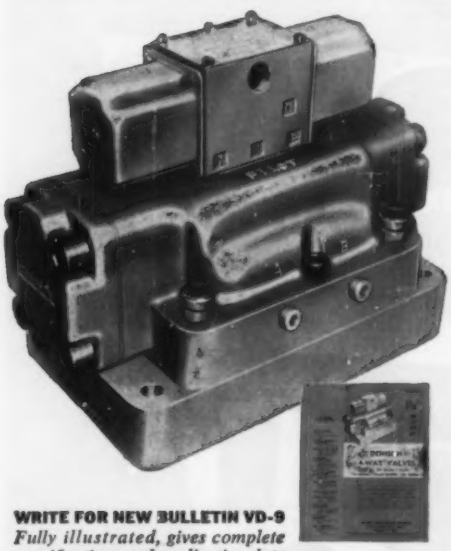
continued on page 61

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

Get 7 important advantages for smooth directional control with these **NEW** 1½" 5000 psi hydraulic...

4-WAY VALVES



WRITE FOR NEW BULLETIN VD-9
Fully illustrated, gives complete specifications and application data for Denison's new 1½-inch 4-way hydraulic valves.

Save space, time and cost on exacting directional hydraulic applications. You can apply shockless, positive directional control to any hydraulic circuit—*by specifying Denison 4-Way Valves.* Stem-operated, pilot-operated, and solenoid-controlled for systems up to 5000 psi, these service-proved valves offer these important features for reliability and design versatility—

Shorter solenoid power stroke permits shorter over-all valve length to speed response. Denison valves deliver fast, rapid-cycle control of flows of 120 gpm.

Drawn steel solenoid covers are secured to body with internal retaining cords. No bulky chains.

Built-in check valve provides pilot pressure without addition of another valve to the system.

Adjustable pilot chokes assure smooth valving action.

Subplate, flange or threaded bodies to suit any type of installation.

Optional lever assembly converts stem-operated valves to manual operation.

Wide choice of spool types and positioning allows handling an unlimited range of applications.

Denison 4-Way Valves also feature large 1½" capacity porting • ample wiring space • interchangeable parts • built to JIC standards. Contact your nearby Denison hydraulic field specialist for details, or write direct to—

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1194 Dublin Road • Columbus 16, Ohio

HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

DENISON
HYDRAULIC POWER

How To Assure
THE MAXIMUM
In High Response Clutch-Brake Systems

The clutch-brake unit you use must provide these basics:

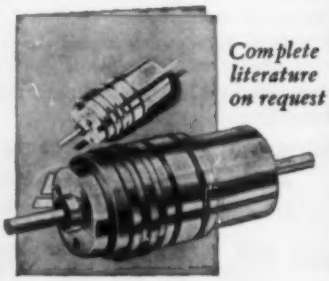
1. minimum armature transfer distance between the brake and clutch housings.
2. clutch and brake friction surfaces held to a high degree of parallelism.
3. no backlash between armature and shaft.
4. clutch and brake friction facings burnished to give rated torque on installation.
5. closely held tolerances and finishes on all important surfaces.
6. minimum armature inertia without any sacrifice in mechanical strength.
7. magnetic circuit ability to respond to the field-forcing technique mentioned below.
8. positive armature release through absence of metal to metal contact and built in return action.

Because of the exclusive patented diaphragm, these features have been built into Simplatrol electric clutches and brakes.

The electric circuitry employed determines to a large extent the clutch reaction time. Reaction time is ordinarily reduced when a high momentary over-voltage is supplied (i.e., a voltage considerably in excess of the steady state rated voltage). Simplatrol can provide helpful suggestions on circuitry. Time required to bring load up to speed is a function of load inertia, r.p.m., and the torque of the clutch-brake.

Simplatrol's engineering organization will work with you to accomplish maximum speed, smoothness and quietness in your clutching and braking. Ask about applications of standard and custom designs in Simplatrol Electric Clutches and Brakes.

Investigate the total efficiency and economy of operation of the single complete unit, in torque ratings of 10 ounce inches to 470 pound feet, in sizes from ⅞" dia. to 12½" dia.



Complete literature on request

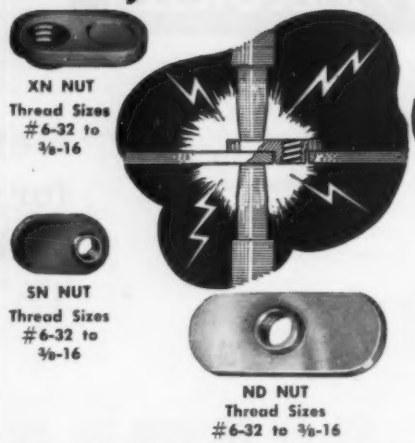
See for yourself the unique advantage of the flexible diaphragm action . . . the *only* moving part in a Simplatrol unit. Get the facts now on Simplatrol clutches and brakes.

Simplatrol products corp.
24 SALISBURY ST., WORCESTER, MASS.
Representation in Key Industrial Areas

871-0

CIRCLE 60 ON READER SERVICE CARD

OHIO SPOT WELDING FASTENERS



If you do spotwelding you can attach OHIO Spotweld Fasteners at the same time for faster, trouble-free assembly.

Samples and information available upon request.

The OHIO WELD FASTENERS Primary Fastener in Fastener Assemblies

THE OHIO NUT AND BOLT CO.
41 FIRST STREET BEREA, OHIO

CIRCLE 69 ON READER SERVICE CARD

---

an infinite variety of standard plastic parts
NO TOOLING COSTS!
HARRY DAVIES MOLDING CO.
1428 N. Wells Street, Chicago 10, Ill.
FREE CATALOG samples on request

CIRCLE 70 ON READER SERVICE CARD

FILTRATION—Reference manual, 16 pp. Bibliography of articles on filtration, filter media, dust collecting, air pollution control, air conditioning, sifting, sieving and straining. Lists subjects of articles, publications in which they appeared, dates of issue, page numbers and synopses of the contents. Snow Filtration Co, Dept X, Cincinnati 2.

Circle 366 on Reader Service Card

SURFACE CHEMISTRY—First issue, newsletter, 2 pp. Discussion of bondability as an elastomer criterion launches periodical on adhesives, coatings, surface treatments, organic chemical specialties, etc. Editor, Chemfacts, Hughson Chemical Co, Erie, Penna.

Circle 367 on Reader Service Card

SINGLE STAGE SERVOVALVE—Bulletin 61-79, 2 pp. Presents specifications and characteristics of valve for electrohydraulic servo systems. Curves show typical flow and typical sinusoidal response characteristics constants. Vickers Inc, Div of Sperry Rand Corp, Detroit 32.

Circle 368 on Reader Service Card

MOTION TRANSDUCERS – Bulletin 001, 2 pp. Lists representative electrical specifications of translatory potentiometers, linear variable differential transformers and translatory velocity transducers. Illustrates and describes several units. Helipot Div, Beckman Instruments Inc, Fullerton, Calif.

Circle 369 on Reader Service Card

LETTERHEAD REQUESTS ONLY
Manufacturers who published following literature asked that requests for copies be made on company letterheads.

ROLLING DIAPHRAGMS – Bulletin 50A, 8 pp. Lists approx 1200 standard sizes (bore sizes from 0.31 to 12.17 in., for strokes from 0.020 to 14.98 in.) and gives operating characteristics of each. Tables show diaphragm class, cylinder bore, piston diameter, effective pressure area, height, total max "half-stroke," and side-wall thickness. Drawings identify five standard classes according to mounting methods. Bellofram Corp, Blanchard Rd, Burlington, Mass.

FOR MORE CATALOGS AND BULLETINS

. . . 1600 of 'em—see your copy of Product Engineering's Mid-Sep 1960 Design Digest. There you will find helpful design literature, classified under 10 different headings, from important manufacturers and suppliers of components, materials, power and local systems, manufacturing processes.

Never Replaced by a Competitor

...the Bruning "Deccto" Cylinder

The fact that "Deccto" cylinders outperform their competition has always been far more important to our customers than their substantially lower cost. In the ten years since these outstanding hydraulic and pneumatic cylinders became standard original equipment on countless installations coast-to-coast, to our knowledge none has yet been replaced by a competitive unit.

We believe the "Deccto" is the most efficient, versatile and competitive cylinder on the market today. It is engineered and manufactured to such advanced concepts that it routinely outperforms conventional, commercial, industrial and military "specification" cylinders weighing two to three times more and costing two to ten times as much.

TEST THE DECCTO YOURSELF. IT WILL PAY YOU MANY TIMES OVER TO TAKE THE TIME TO DO SO.

- 1.5" through 4" bore ((mirror finished)
- 5,000 - 8,000 P. S. I.
- J. I. C. Interchangeability
- Unexcelled for compactness and installational flexibility
- Either single or double action
- Best value on the market

Call collect or write today. "Deccto" cylinders could be saving you thousands of dollars. Our files support this claim, and we will be happy to send you full particulars.

THE BRUNING COMPANY

LINCOLN, NEBRASKA
Phone – HE 5-3511 • TWX – LI 8151

Dev. Eng'r.

We need an engineer to fill a key management position. He will be expected to make technical contributions in product development. Gillette, a worldwide organization, can offer him unlimited professional challenge. Please send your resume in complete confidence to:

D. DeHart
Gillette Safety Razor Company
Boston 6, Massachusetts

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

A BRAND NEW —EXCLUSIVE— READER SERVICE WILL BE ADDED TO THE DESIGN DIGEST ISSUE

A new, easy way for you to get suppliers' catalogs and bulletins—more than 2000 of them—indexed by product and alphabetically by company name. An exclusive PRODUCT ENGINEERING service:

THE DESIGN ENGINEERS' PRODUCT CATALOG INDEX

This will be the most complete index of available product data ever offered to Design Engineers. Be sure of your personal copy of this popular issue and the Product Catalog Index. Send in the subscription card in this issue —today!

THE DESIGN DIGEST ISSUE
September 4, 1961

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

A

Aluminum Co. of America.....9-10
American Standard Controls Div., American Radiator & Standard Corp. .....4th Cover
Anaconda American Brass Co..2nd Cover
Anchor Coupling Co., Inc..... 23

B

Bruning Co., The..... 61
Bruning Co., Inc., Charles..... 6-7

D

Davies Molding Co., Harry..... 60
Denison Engineering Div., American Brake Shoe Co..... 59
Dixon Corp. 22

G

Goodrich Chemical Co., B. F., Plastic Materials Div. .....3rd Cover

L

Linde Co., Div. of Union Carbide Corp. 55
Link-Belt Co. 3

M

Minnesota Mining & Mfg. Co., Adhesives, Coatings, Sealers Div..... 57
Minnesota Rubber Co..... 2

N

National Standard Co.....20-21

O

Ohio Nut & Bolt Co..... 60

P

Parker Seal Co. 14-15

S

Simplatrol Products Corp..... 60
Superior Carbon Products, Inc..... 22

U

U. S. Steel Corp.....49-53

V

Vulcan Electric Co..... 24

LLOYD R. LAWRENCE *advertising sales manager*

P. F. PRITCHARD *manager, market development and circulation*

RUSSELL T. DOUGLAS *business manager*

ADVERTISING SALES STAFF

ATLANTA 9 . . . Ray K. Burnet, 1375 Peachtree St., N.E., 875-0523

BOSTON 16 . . . M. A. Williamson, Jr., McGraw-Hill Bldg, Copley Square, Congress 2-1160

CHICAGO 11 . . . Mid-Western Adv Sales Manager, A. E. Meanor; L. Anderson, T. R. Coash, 645 N. Michigan Ave, Mohawk 4-5800

CINCINNATI 2 . . . P. B. Robinson, Carew Tower, Garfield 1-5474

CLEVELAND 13 . . . 1164 Illuminating Bldg, 55 Public Sq. Superior 1-7000

DALLAS 1 . . . Frank LeBeau, 901 Vaughn Bldg, 1712 Commerce St, Riverside 7-5117

DENVER 2 . . . John W. Patten, Tower Bldg, 1700 Broadway, Alpine 5-2981

DETROIT 26 . . . P. B. Robinson, 856 Penobscot Bldg, Woodward 2-1793

HOUSTON 25 . . . Don Hanson W-724 Prudential Bldg, Jackson 6-1281

LOS ANGELES 17 . . . Robert Obenour, 1125 West 6th St, Huntley 2-5450

NEW YORK 36 . . . B. K. Adams, F. J. McKinley, 500 Fifth Ave, Oxford 5-5959

PHILADELPHIA 3 . . . John B. Lewis, H. M. Nicholson, 6 Penn Center Plaza, Locust 8-4330

PITTSBURGH 22 . . . C. F. Leveroni, 4 Gateway Center, Express 1-1314

PORTLAND 4, ORE. . . . Scott Hubbard, 445 Pacific Bldg, Capital 3-5118

ST. LOUIS 8 . . . T. R. Coash, 3615 Olive St, Continental Bldg, Jefferson 5-4867

SAN FRANCISCO 11 . . . J. J. Hernan, 255 California St, Douglas 2-4660

SUBSCRIPTIONS. Send subscription correspondence and change of address to Fulfillment Manager, PRODUCT ENGINEERING, 330 W. 42nd St., New York 36, N. Y. Subscribers should notify Fulfillment Manager promptly of any change of address including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Since copies are addressed one to two issues in advance please allow one month for change of address to become effective. Subscriptions are solicited only from executives, engineers and consultants engaged in the design of machinery and other engineered products. Position and company connection must be indicated on subscription orders.

OFFICERS OF THE PUBLICATIONS DIVISION: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice-Presidents; John R. Callaham, Vice-President and Editorial Director; Joseph H. Allen, Vice-President and Director of Advertising Sales; A. R. Venezian, Vice-President and Circulation Coordinator. OFFICERS OF THE CORPORATION: Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice-Presidents; J. Keith Goodrich, Vice-President and Treasurer; John J. Cooke, Secretary.

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.
Employment Opportunities 62

add to your DESIGN REFERENCE FILE from t

EDITORIAL REPRINTS AVAILABLE

Single reprints free

597—THE YO-YO DESPINNER STOPS ROTATING MASSES

Two small masses unwind from a spinning body and stops it in a fraction of a second.

598—STANDARDS FOR PRINTED WIRING BOARDS

Five different military standards are boiled down to a guide for industrial service.

599—THE RIGHT INSULATION

A simple method based on two large tables, helps find the best one for your application.

600—SELECTION GUIDE TO HIGH-DAMPING MATERIALS

Basic data on over 50 materials and their use as viscoelastic dampers.

601—PRECISION BALL SCREWS

Load and speed characteristics and a simplified 10-step design procedure.

602—WHICH SHOCK-ABSORBING SYSTEM?

A comparison table plus a few quick calculations with these efficiency factors will help choose the best for your design.

603—HOW TO SELECT A FLOWMETER

Roundup of available types and simplified selection procedure.

604—DEVELOPMENTS IN LUBRICATION

A wealth of new equations, design charts and performance data from this year's ASLE meeting.

605—FIBERGLASS-REINFORCED THERMOPLASTICS

They are closing the performance gap between thermoplastics and metals.

606—THREADED INSERTS

Types available, factors governing selection, strength and cost characteristics.

607—SYNCHRONIC INDEX OF GEAR TRAINS

Method finds turns of input before gear positions repeat.

608—HOW TO LISTEN—AND REMEMBER

Here's what the psychologists say will improve your "listening power."

609—DON'T OVERLOOK ELECTROFORMING

It needn't be costly with these new mandrel systems, plating alloys and design methods.

610—SOLDERED ELECTRICAL CONNECTIONS

A complete design procedure covering all types.

611—WHICH CLUTCH?

Three-step procedure pinpoints type, location and size.

612—VALUE IN DESIGN

Present and future potentialities of specialist services in design engineering.

613—FAILURE ANALYSIS

Where and how to look for the trouble in new miniaturized designs.

614—TOMORROW'S POWER SOURCES

14 mobile power sources to generate from 1 to 500 hp.

615—NEW GEAR CLASSIFICATION

Sets up 16 quality classes, material codes and new backlash tolerances.

616—UNCONVENTIONAL POWER SOURCES

8 laboratory curiosities promise power for the future.

617—METAL FINISHES

From paints to bonded lubes—what they can do, how they compare.

618—MECHANICAL COUNTERS

What is available for over 1000 rpm—the types, their strengths and weaknesses.

619—NONSTANDARD SPUR GEARS

Altering pressure angle offers center-distance freedom.

620—HOT AIR FOR TESTING

Selection tables for any temperature to 500,000 F.

(please print or type) *If this is change of address, check box* ☐

Name_____ Title_____

Company_____

Street_____ Home ☐ Plant ☐_____

City_____ Zone_____ State_____

AND MAY WE HAVE THIS INFORMATION ON YOUR COMPANY

1	24	47	70	93	116	139	162	309	332	355	378
2	25	48	71	94	117	140	163	310	333	356	379
3	26	49	72	95	118	141	164	311	334	357	380
4	27	50	73	96	119	142	165	312	335	358	381
5	28	51	74	97	120	143	166	313	336	359	382
6	29	52	75	98	121	144	167	314	337	360	383
7	30	53	76	99	122	145	168	315	338	361	384
8	31	54	77	100	123	146	169	316	339	362	385
9	32	55	78	101	124	147	170	317	340	363	386
10	33	56	79	102	125	148	171	318	341	364	387
11	34	57	80	103	126	149	172	319	342	365	388
12	35	58	81	104	127	150	173	320	343	366	389
13	36	59	82	105	128	151	174	321	344	367	390
14	37	60	83	106	129	152	175	322	345	368	391
15	38	61	84	107	130	153	300	323	346	369	392
16	39	62	85	108	131	154	301	324	347	370	393
17	40	63	86	109	132	155	302	325	348	371	394
18	41	64	87	110	133	156	303	326	349	372	395
19	42	65	88	111	134	157	304	327	350	373	396
20	43	66	89	112	135	158	305	328	351	374	397
21	44	67	90	113	136	159	306	329	352	375	398
22	45	68	91	114	137	160	307	330	353	376	399
23	46	69	92	115	138	161	308	331	354	377	400

MAJOR PRODUCT MANUFACTURED

- ☐ Agricultural Equipment
- ☐ Aircraft, Missiles, Rockets
- ☐ Appliances, Radio, TV
- ☐ Auto, RR, Trans. Equip.
- ☐ Business & Commercial Machines
- ☐ Construction, Mining Equip.
- ☐ Elect. Machinery & Apparatus
- ☐ Industrial Machinery & Equip.
- ☐ Instruments & Scientific Equip.
- ☐ Ordnance & Accessories
- ☐ Other Fabricated Metal Pdts.

MULTIPLE PRODUCT ADS

Key No. Specific Product

_____ _____

_____ _____

REPRINTS

597	601	605	609	613	617
598	602	606	610	614	618
599	603	607	611	615	619
600	604	608	612	616	620

FOR YOU: USEFUL NEW DESIGN IDEAS!

Have *your personal* copy of PRODUCT ENGINEERING sent each week to your office or home. ACT NOW. Fill out this card today. Don't miss a single issue.

U.S. only ☐ **1 year—NOW $3** ☐ **2 years—NOW $4**

Canada **1 year—$5** **2 years—$8**

☐ Payment Enclosed ☐ Bill me

Name_____ Your Title_____

Home ☐_____

Address Office ☐_____

City_____ Zone_____ State_____

Company Name_____ Your Dept._____

Products Mfgd. or Designed_____

Please check your job function:

- ☐ Product Design Engineering
- ☐ Research & Development Engineering
- ☐ Manufacturing
- ☐ Administrative Engineering
- ☐ Company Management

Other_____

U-

NEW COMPONENTS

RESEARCH AND TEST EQUIPMENT
324—Transistorized Strain Indicator

METALS AND ALLOYS
312—Thermocouple Material

NON-METALLIC MATERIALS, FINISHES
312—Thermocouple Material

POWER TRANSMISSION
308—Hi-speed Backstop Clutches
311—20° Pressure Angle Gears
322—One-piece Steel Pulley

MECHANICAL PARTS
313—Hydraulic Seals and Packings
318—Miniature Pitch Chain

FASTENING AND JOINING
306—Mounting Screws
310—Hi-temp Adhesive
315—Expansion Insert

MOTORS, ENGINES AND CONTROLS
300—Oil-filled Synchronous Timing Motor
301—Heavy-duty Linear Actuator
302—Subminiature Snap-action Switch
301—Reset Dial Timer

ELECTRICAL, ELECTRONIC COMPONENTS
302—Subminiature Snap-action Switch
303—Magnetic Pickup
305—Pressure Cell
309—Reset Dial Timer
312—Thermocouple Material
317—Transistor Ac Voltmeters
320—Tubular Heaters
321—Panel Meters
323—Magnetic Latching Relay

HYDRAULIC, PNEUMATIC EQUIPMENT
304—Hydraulic Rams
305—Pressure Cell
307—Compressed Air Line Lubricator
313—Hydraulic Seals and Packings
314—Motorized Butterfly Valve
316—Single-purpose Solenoid
319—Hydraulic Pumping System

NEW CATALOGS AND BULLETINS

RESEARCH AND TEST EQUIPMENT
364—Testing Machines, 8 pp, Testing Machines Inc

METALS AND ALLOYS
357—Metal Finishing, 4 pp, Lea Mfg Co
360—Strain-tempered Steel Bars, 4 pp, SAE Steels Inc

NON-METALLIC MATERIALS, FINISHES
367—Surface Chemistry, 2 pp, Hughson Chemical Co

FABRICATION PROCESSES AND PRODUCTION
357—Metal Finishing, 4 pp, Lea Mfg Co

POWER TRANSMISSION
362—Drive Tensioners, 4 pp, Maurey Mfg Corp

MECHANICAL PARTS
351—High-pressure Seals, Fasteners, APM Corp
353—Casters and Wheels, 48 pp, Hamilton Caster & Mfg Co
359—Molded Cups, 4 pp, Garlock Inc
363—Spacers and Posts, 4 pp, Angler Industries Inc

FASTENING AND JOINING
351—High-pressure Seals, Fasteners, 16 pp, APM Corp
352—Threaded Inserts, 28 pp, Newton Insert Co

ELECTRICAL, ELECTRONIC COMPONENTS
356—Circuit Breakers, 32 pp, Westinghouse Electric Corp
358—Selenium Photovoltaic Cells, 6 pp, Daystrom Inc
361—Selenium Rectifiers, 4 pp, Syntron Co
365—Single-circuit Shallow Contact Blocks, 2 pp, General Electric Co
368—Single Stage Servovalve, 2 pp, Vickers Inc, Div of Sperry Rand Corp
369—Motion Transducers, 2 pp, Beckman Instruments Inc

HYDRAULIC, PNEUMATIC EQUIPMENT
350—Self-sealing Couplings, 20 pp, Aeroquip Corp
359—Molded Cups, 4 pp, Garlock Inc
366—Filtration, 16 pp, Snow Filtration Co
368—Single Stage Servovalve, 2 pp, Vickers Inc, Div of Sperry Rand Corp

(please print or type) *If this is change of address, check box* ☐

Name _____ Title _____

Company _____

Street _____ Home ☐ Plant ☐ _____

City _____ Zone _____ State _____

AND MAY WE HAVE THIS INFORMATION ON YOUR COMPANY

1	24	47	70	93	116	139	162	309	332	355	378
2	25	48	71	94	117	140	163	310	333	356	379
3	26	49	72	95	118	141	164	311	334	357	380
4	27	50	73	96	119	142	165	312	335	358	381
5	28	51	74	97	120	143	166	313	336	359	382
6	29	52	75	98	121	144	167	314	337	360	383
7	30	53	76	99	122	145	168	315	338	361	384
8	31	54	77	100	123	146	169	316	339	362	385
9	32	55	78	101	124	147	170	317	340	363	386
10	33	56	79	102	125	148	171	318	341	364	387
11	34	57	80	103	126	149	172	319	342	365	388
12	35	58	81	104	127	150	173	320	343	366	389
13	36	59	82	105	128	151	174	321	344	367	390
14	37	60	83	106	129	152	175	322	345	368	391
15	38	61	84	107	130	153	300	323	346	369	392
16	39	62	85	108	131	154	301	324	347	370	393
17	40	63	86	109	132	155	302	325	348	371	394
18	41	64	87	110	133	156	303	326	349	372	395
19	42	65	88	111	134	157	304	327	350	373	396
20	43	66	89	112	135	158	305	328	351	374	397
21	44	67	90	113	136	159	306	329	352	375	398
22	45	68	91	114	137	160	307	330	353	376	399
23	46	69	92	115	138	161	308	331	354	377	400

MAJOR PRODUCT MANUFACTURED

- ☐ Agricultural Equipment
- ☐ Aircraft, Missiles, Rockets
- ☐ Appliances, Radio, TV
- ☐ Auto, RR, Trans. Equip.
- ☐ Business & Commercial Machines
- ☐ Construction, Mining Equip.
- ☐ Elect. Machinery & Apparatus
- ☐ Industrial Machinery & Equip.
- ☐ Instruments & Scientific Equip.
- ☐ Ordnance & Accessories
- ☐ Other Fabricated Metal Pdts.

MULTIPLE PRODUCT ADS

Key No. Specific Product

REPRINTS

597	601	605	609	613	617
598	602	606	610	614	618
599	603	607	611	615	619
600	604	608	612	616	620

(please print or type) *If this is change of address, check box* ☐

Name _____ Title _____

Company _____

Street _____ Home ☐ Plant ☐ _____

City _____ Zone _____ State _____

AND MAY WE HAVE THIS INFORMATION ON YOUR COMPANY

1	24	47	70	93	116	139	162	309	332	355	378
2	25	48	71	94	117	140	163	310	333	356	379
3	26	49	72	95	118	141	164	311	334	357	380
4	27	50	73	96	119	142	165	312	335	358	381
5	28	51	74	97	120	143	166	313	336	359	382
6	29	52	75	98	121	144	167	314	337	360	383
7	30	53	76	99	122	145	168	315	338	361	384
8	31	54	77	100	123	146	169	316	339	362	385
9	32	55	78	101	124	147	170	317	340	363	386
10	33	56	79	102	125	148	171	318	341	364	387
11	34	57	80	103	126	149	172	319	342	365	388
12	35	58	81	104	127	150	173	320	343	366	389
13	36	59	82	105	128	151	174	321	344	367	390
14	37	60	83	106	129	152	175	322	345	368	391
15	38	61	84	107	130	153	300	323	346	369	392
16	39	62	85	108	131	154	301	324	347	370	393
17	40	63	86	109	132	155	302	325	348	371	394
18	41	64	87	110	133	156	303	326	349	372	395
19	42	65	88	111	134	157	304	327	350	373	396
20	43	66	89	112	135	158	305	328	351	374	397
21	44	67	90	113	136	159	306	329	352	375	398
22	45	68	91	114	137	160	307	330	353	376	399
23	46	69	92	115	138	161	308	331	354	377	400

MAJOR PRODUCT MANUFACTURED

- ☐ Agricultural Equipment
- ☐ Aircraft, Missiles, Rockets
- ☐ Appliances, Radio, TV
- ☐ Auto, RR, Trans. Equip.
- ☐ Business & Commercial Machines
- ☐ Construction, Mining Equip.
- ☐ Elect. Machinery & Apparatus
- ☐ Industrial Machinery & Equip.
- ☐ Instruments & Scientific Equip.
- ☐ Ordnance & Accessories
- ☐ Other Fabricated Metal Pdts.

MULTIPLE PRODUCT ADS

Key No. Specific Product

REPRINTS

597	601	605	609	613	617
598	602	606	610	614	618
599	603	607	611	615	619
600	604	608	612	616	620

PERSONAL READER SERVICE

use these prepaid cards

for additional product design data on

Brochures on advertised products
New materials and components
Free article reprints
New catalogs and bulletins

Your OWN subscription to:

PRODUCT ENGINEERING

OPEN THIS FOLDER FOR MAXIMUM USE WHEN CHECKING ISSUE

Issue of July 31, 1961
PRODUCT ENGINEERING
Card expires September 29, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States
Postage will be paid by Reader Service Department

Inquiries Service Department
PRODUCT ENGINEERING
P. O. BOX 601
RIDGEFIELD, CONNECTICUT

CIRCLE
number that corresponds to numbers printed under each advertisement, new component or bulletin

PRINT OR TYPE
your name, company and address

TEAR OFF AND MAIL
we'll gladly do the rest

Issue of July 31, 1961
PRODUCT ENGINEERING
Card expires September 29, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States
Postage will be paid by Reader Service Department

Inquiries Service Department
PRODUCT ENGINEERING
P. O. BOX 601
RIDGEFIELD, CONNECTICUT

CIRCLE 174 →

INDEX of products advertised in this issue

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD.

A

Adhesives 57
Aluminum Alloys 9–10
Assemblies
  Electrical 22

B

Brakes
  Electric 60

C

Clutches
  Electrical 60
Contact & Contact Materials 22
Controls
  Hydraulic 59
Copper & Copper Alloys ..... 2nd Cover
Couplings
  Hose 23
  Tube 23
Cylinders
  Hydraulic 61
  Pneumatic 61

D

Drafting
  Supplies 6–7

F

Fastening Methods 60
Fittings, Hose, Pipe & Tube 23

H

Hard Surfacing 55
Heating Units 24

M

Moldings
  Plastics (see Plastic Parts)
  Rubber (see Rubber Parts)
Motors, Hydraulic 69

N

Nuts 60

P

Pins 60
Plastic Parts 22, 60
Pumps
  Liquid 59

R

Reproduction Supplies 6–7
Rubber ..... 4th Cover
Rubber Parts 2

S

Seals 2, 14–15
Special Shapes & Sections 49–53
Speed Increasers & Reducers 5
Steel
  Alloy 49–53
  Stainless 49–53
Switches ..... 3rd Cover

T

Tapes 22
Thermometers ..... 3rd Cover
Tracing Paper 6–7

V

Valves
  Hydraulic 59
  Solenoid ..... 3rd Cover

W

Wear Materials 55
Welding
  Nuts 60
Wire 20–21

Issue of July 31, 1961
PRODUCT ENGINEERING
Card expires September 29, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage will be paid by Reader Service Department

Inquiries Service Department
PRODUCT ENGINEERING
P. O. BOX 601
RIDGEFIELD, CONNECTICUT

Issue of July 31, 1961
PRODUCT ENGINEERING
Card expires September 29, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

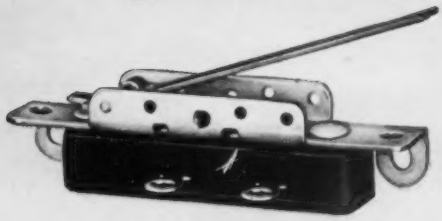
Postage will be paid by Reader Service Department

Inquiries Service Department
PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

BASIC for Product Engineers

Design engineers searching for components to act as nerve centers for their products are sure to find the value of these American-Standard Controls Division products. This is true of anybody who must control or indicate the pressure or temperature of gases and fluids or electrical energy.

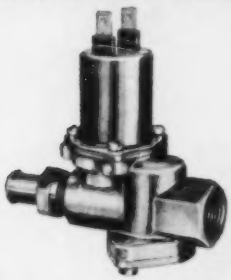
TyniSwitch



Here is a precision miniature snap switch available with a wide variety of actuators which will shave space, yet perform dependably hundreds of thousands of times. It makes and breaks positively *without bounce!* Ratings up to 15 amperes.

AMERICAN-Standard
CONTROLS DIVISION

Solenoid Valves



Widely used in the appliance and vending machine industry, these valves have the ability to provide a predetermined liquid flow without regard to pressure. Brass, stainless steel or nylon bodies. Wide selection of mounting brackets, line connections and electrical specifications.

AMERICAN-Standard
CONTROLS DIVISION

You can get detailed information on any of these products by writing American-Standard Controls Division, 5900 Trumbull, Detroit 8, Michigan.

Remote Reading Thermometers

There are practically no limits as to the specialized applications for Rochester thermometers. This remote reading thermometer is hermetically sealed, is available in a wide variety of ranges and capillary tube lengths.

AMERICAN-Standard
CONTROLS DIVISION

AMERICAN-Standard
CONTROLS DIVISION

B.F.Goodrich

Here's Estane: a tough, abrasion-resistant polyurethane elastomer that is thermoplastic!

Speeds up molding and extrusion. With Estane, you can recycle waste and scrap stock accumulated in normal fabrication. Estane can be extruded, injection-molded, milled, calendered or used in solvent systems using standard thermoplastic processing techniques. Estane materials behave much like vinyl in processing—same equipment, similar settings. Estane polyurethane comes in tough, rubbery, clear granules, ranging in hardness from 65 to 95 Durometer "A". All have a tensile strength of over 5000 psi and an elongation over 500%. Fuel and oil-resistance, cut and tear-resistance, abrasion-resistance and low-temperature flexibility are all excellent.

Estane provides cost savings because of its unique properties and simplified handling procedures. Faster cycles and recycled processing scrap produced a demonstrated 50% cost reduction in one operation. Available polymers and compounds provide profit opportunities in many applications, such as shoe soles, heels and uppers; in elastic thread, for wire and cable jacket, tubing and hose, and many coating applications.

For information about the several Estane materials now available, write Department RE-1, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical
a division of The B.F.Goodrich Company

Estane
Reg. U. S. Pat. Off.
Polyurethane Materials

CIRCLE 175 ON READER SERVICE CARD